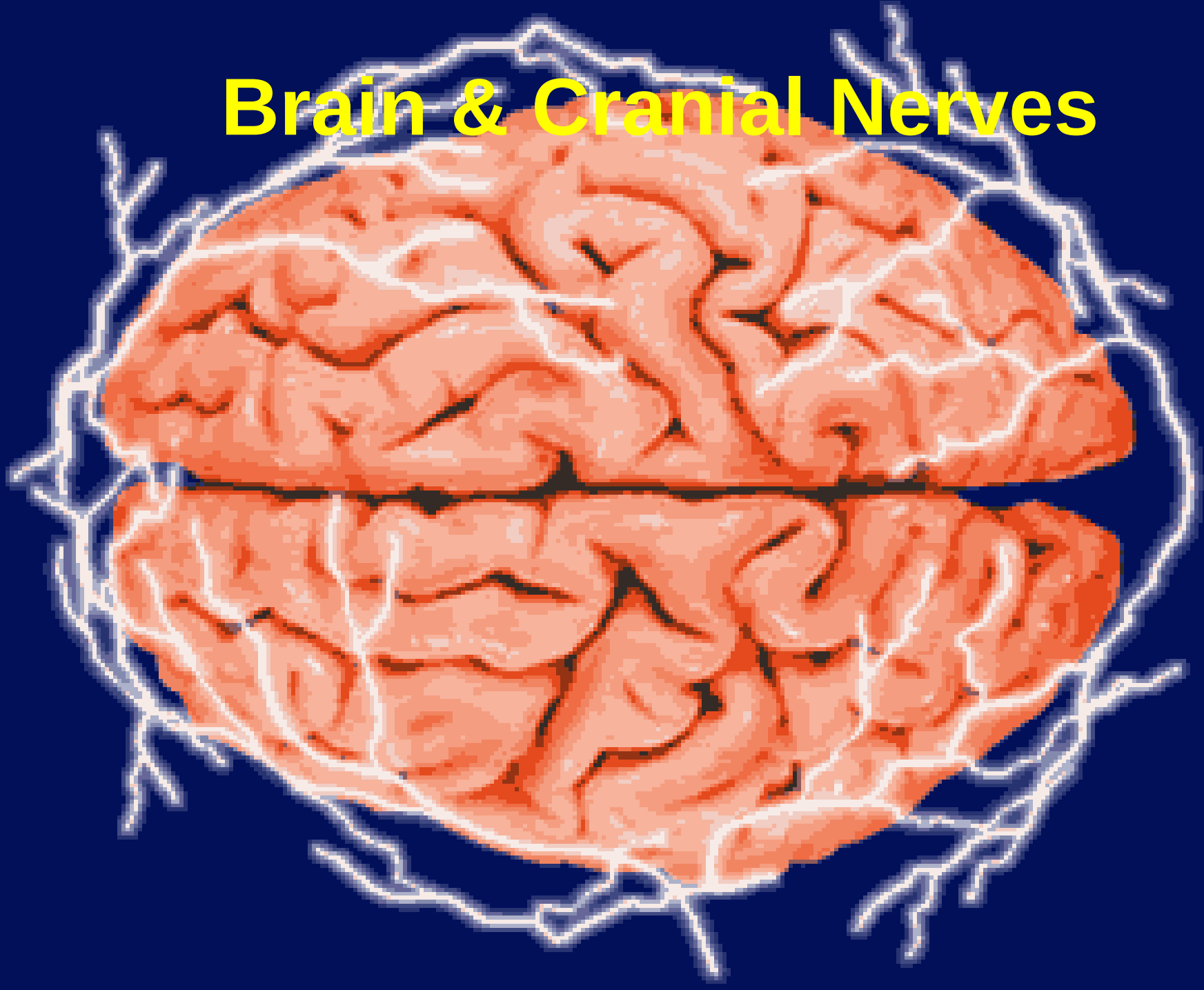
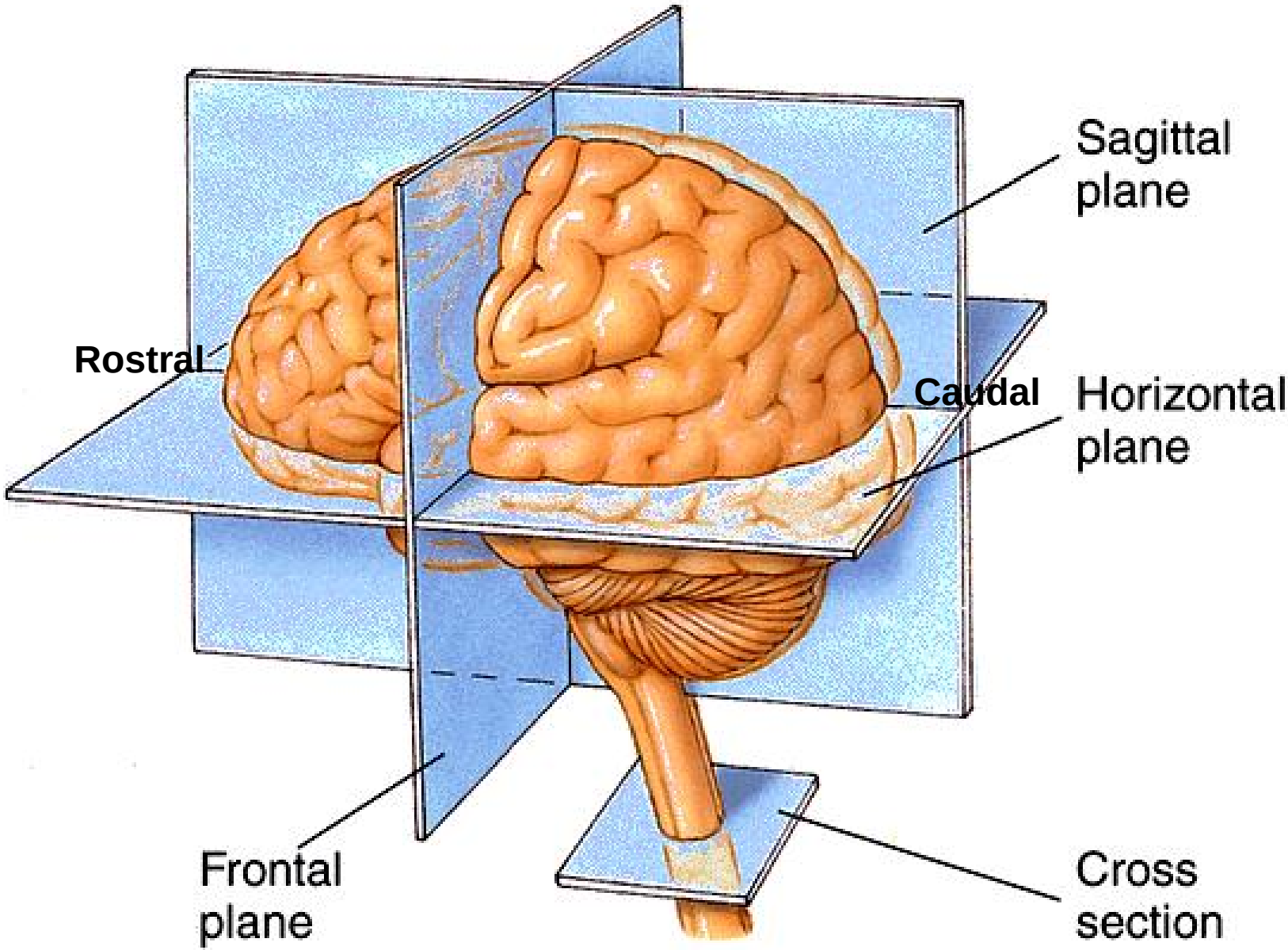
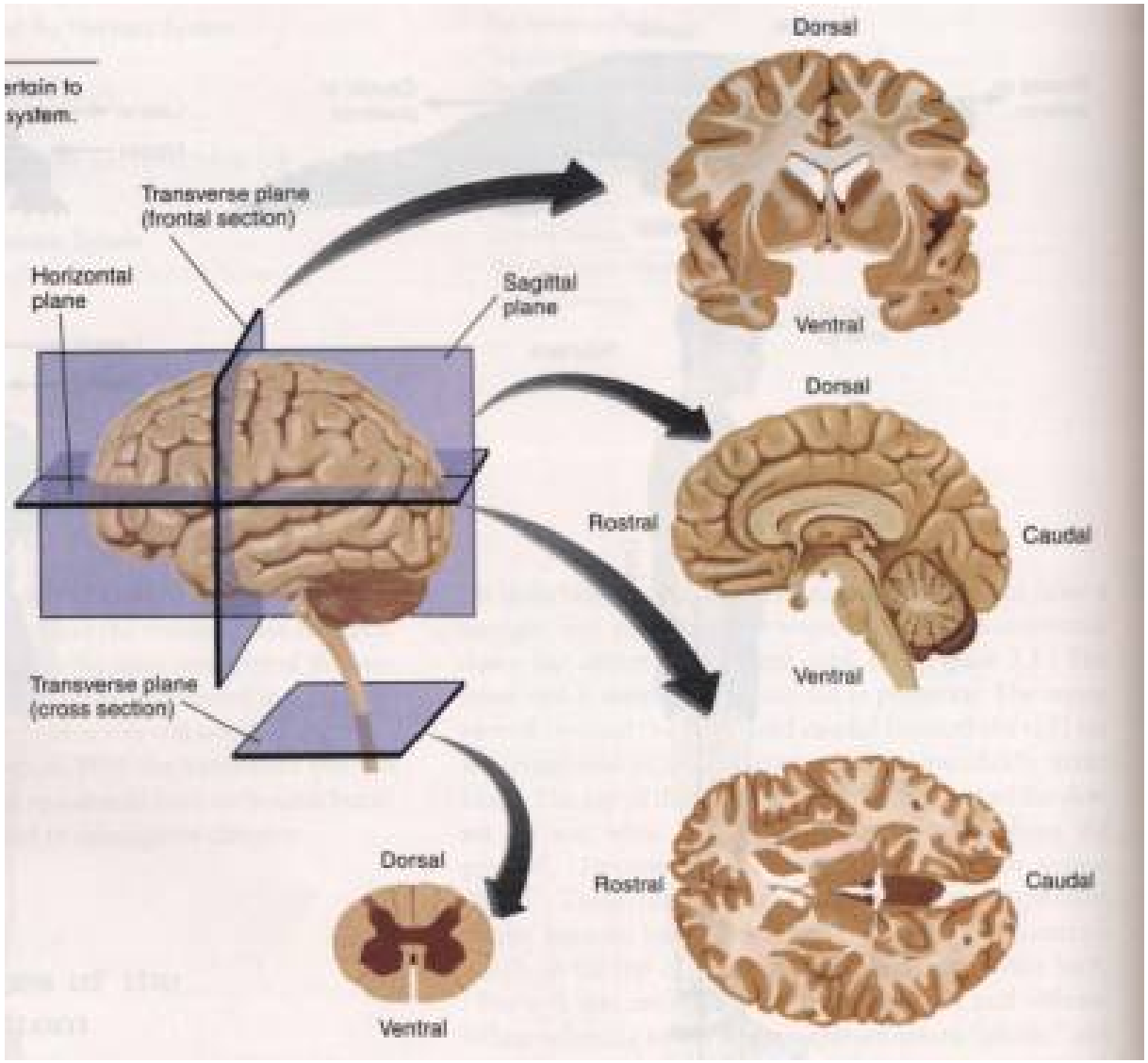
Brain & Cranial Nerves



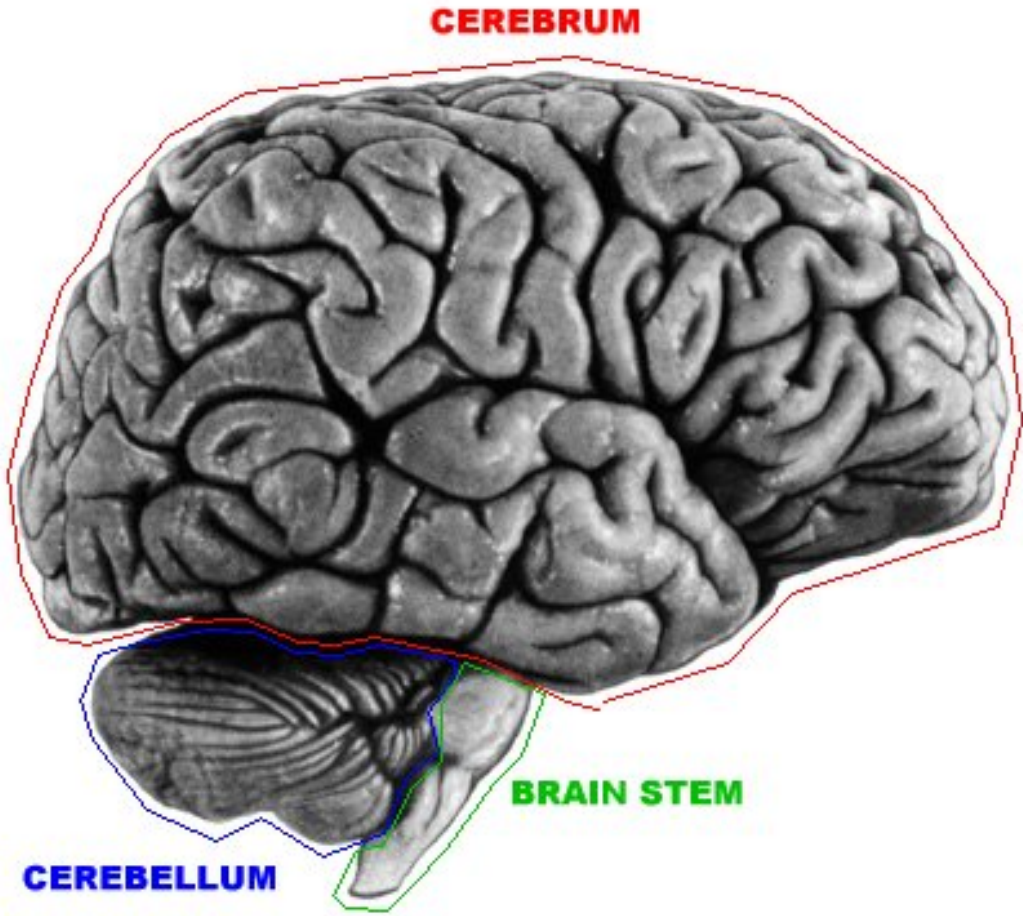
▶ Planes of the Human Brain




ertain to
system.
Transverse plane
(frontal section)
Horizontal
plane
Sagittal
plane
Transverse plane
(cross section)
Dorsal
Ventral
Dorsal
Rostral
Caudal
Ventral
Dorsal
Ventral
Rostral
Caudal

Landmarks of the Brain

- The brain is divided into three major portions
  - cerebrum
  - cerebellum
  - brainstem



Embryonic Development

•The nervous system develops from **ectoderm**, the outermost germ layer of an embryo

•By the third week of development, a dorsal streak called the **neuroectoderm** appears along the length of the embryo

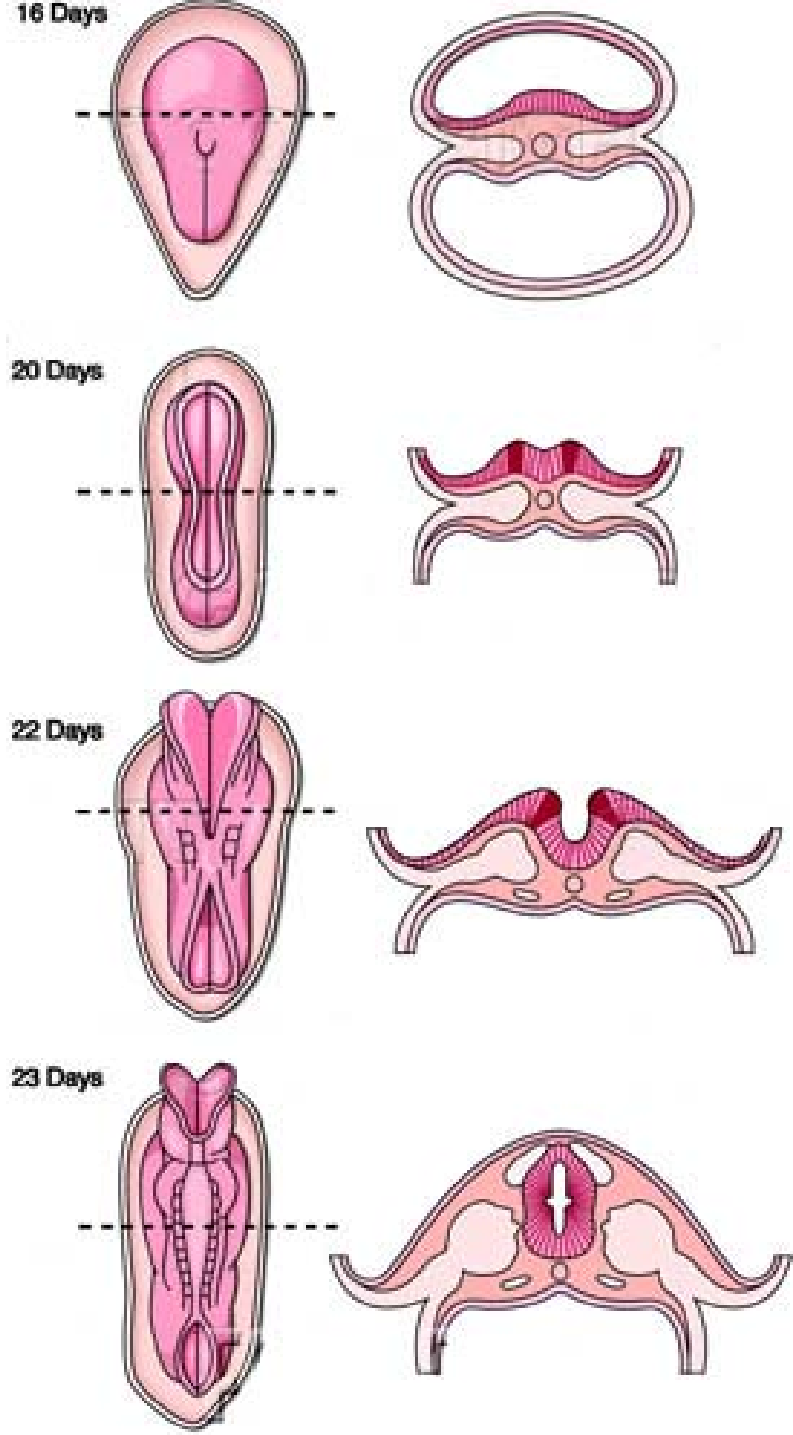
•The neuroectoderm eventually thickens to form the **neural plate**

- •gives rise to all neurons and glial cells except the microglia (comes from mesoderm)

•The neural plate sinks and forms a neural groove with a raised neural fold along each side

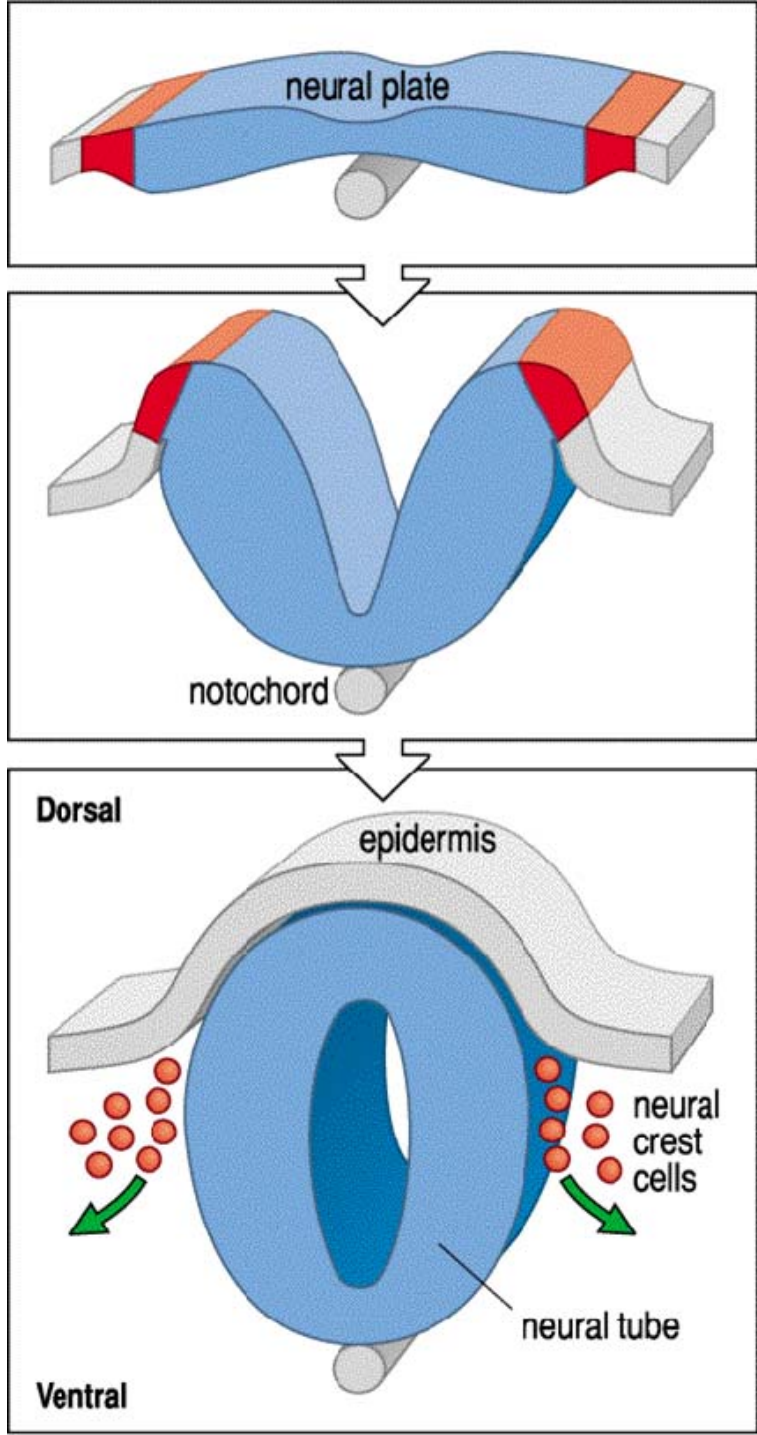
•The neural fold fuses along the midline creating a hollow channel called the **neural tube**.

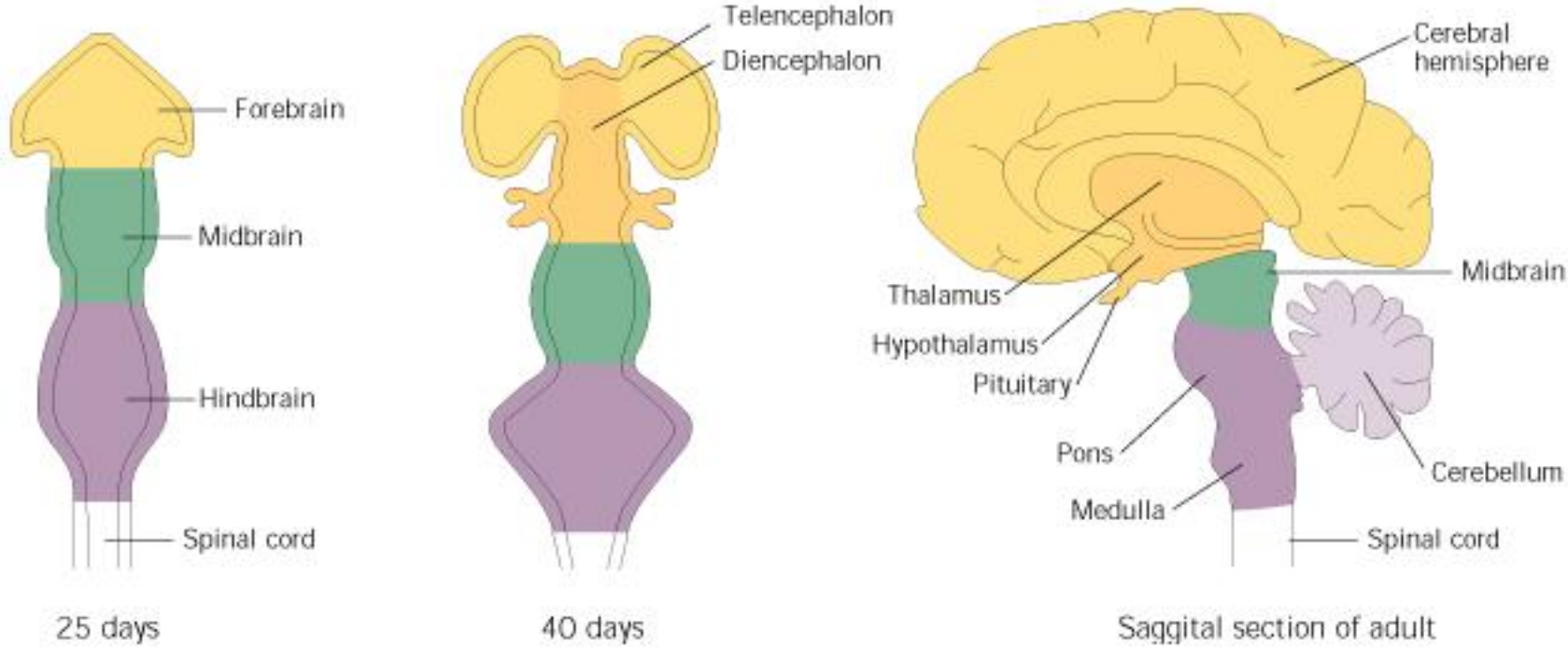
- •forms the motor nerves, the central of the cord, and the ventricles of the brain



As the neural tube develops, ectodermal cells along the margin, called the **neural crest**, separate to other locations and becomes

- •neural sensory cells,
- •sympathetic neurons,
- •Schwann cells,
- •and other types of cells

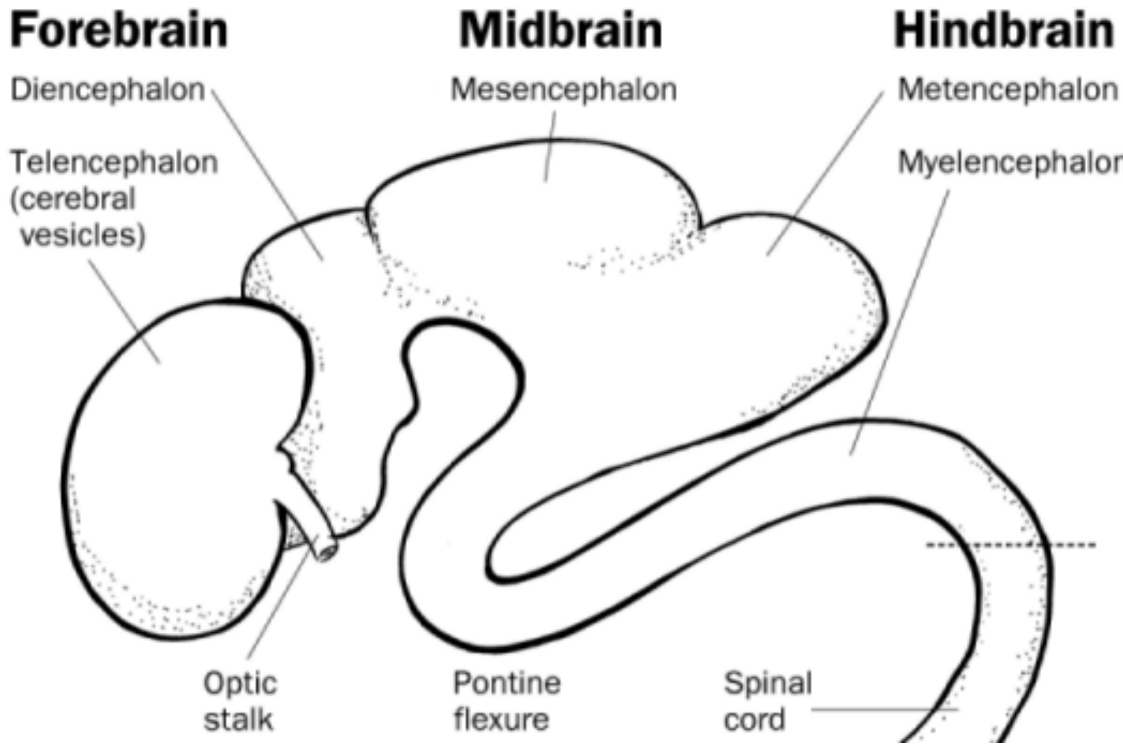


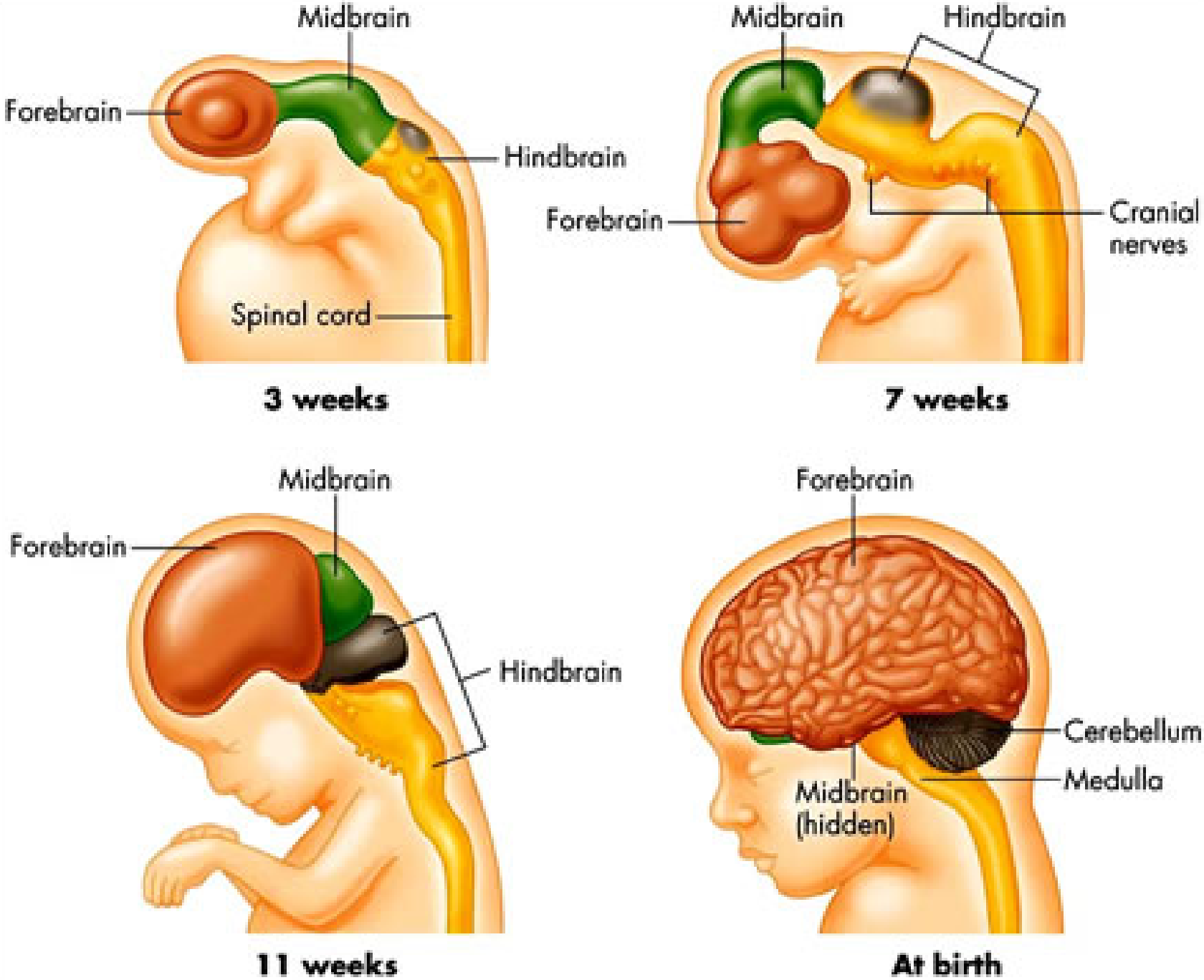


By the end of the fourth week, the neural tube exhibits the three dilations called the forebrain, midbrain, and hindbrain

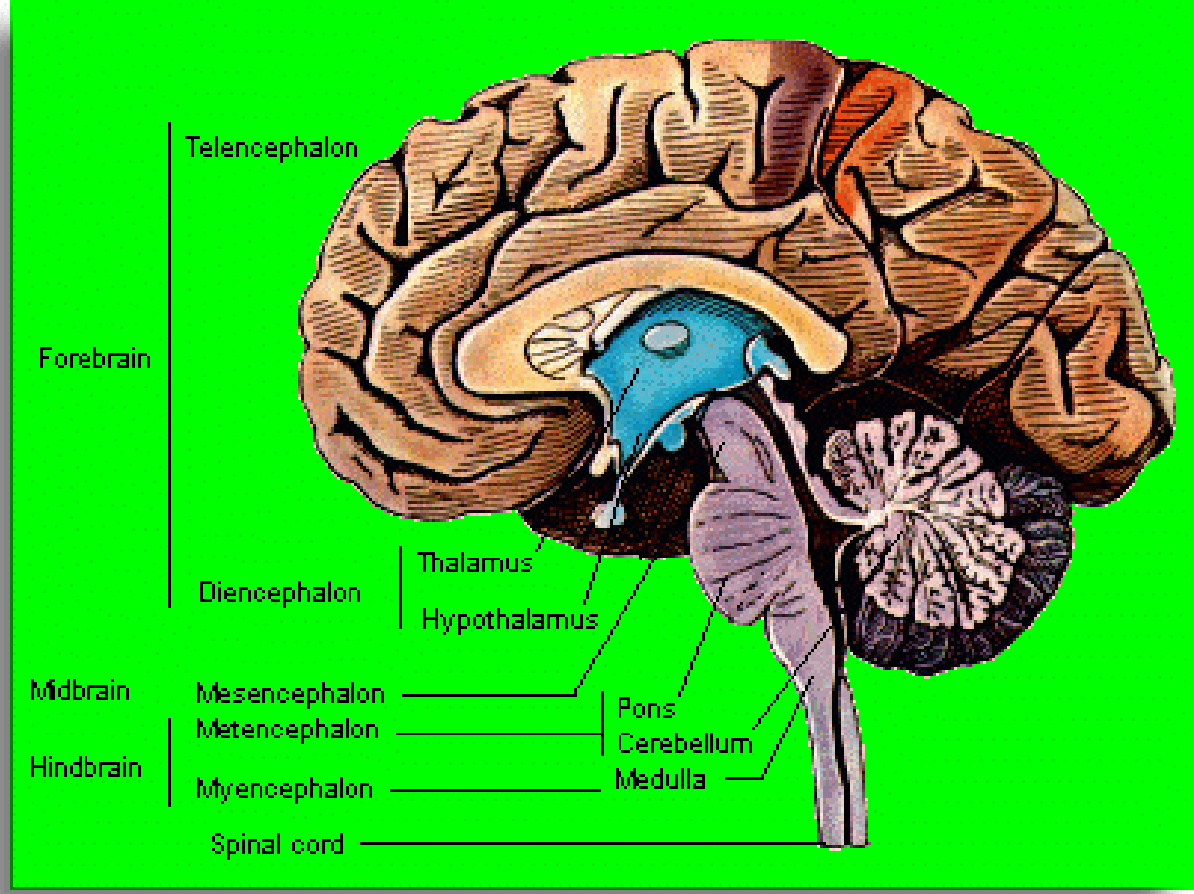
Gross Anatomy of the Brain

- **Forebrain**- (Prosencephalon)
  - telencephalon
    - Cerebral Hemispheres
      - Cerebral Cortex
        Basal ganglia
        Basal forebrain nuclei
        Amygdaloid Nucleus
  - diencephalon
    - Thalamus and Hypothalamus
- **Midbrain**- mesencephalon
- **Hindbrain**- (Rhombencephalon)
  - metencephalon
    - Pons and Cerebellum
  - mylencephalon
    - Medulla Oblongata



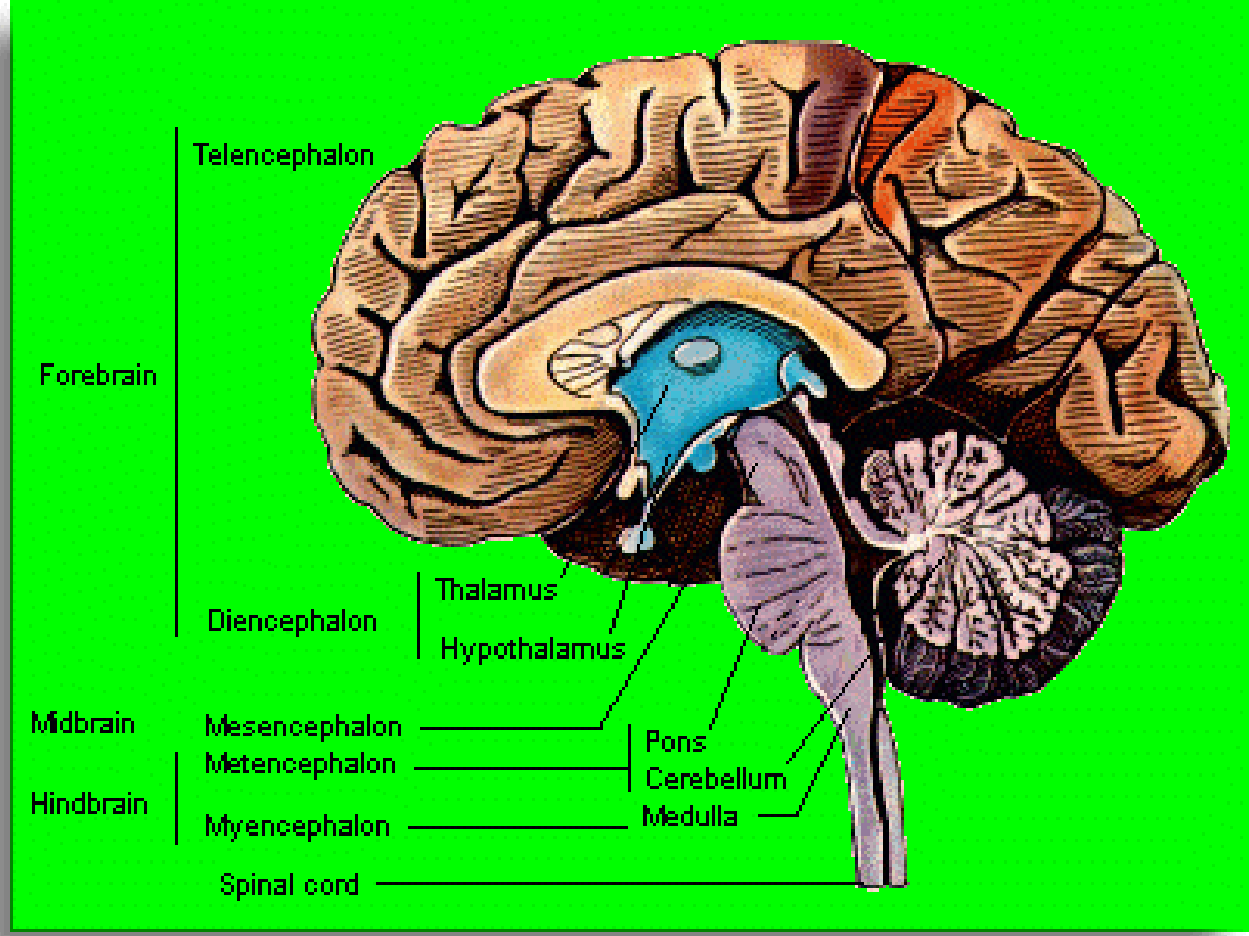

Midbrain
Forebrain
Hindbrain
Spinal cord
3 weeks
Midbrain
Hindbrain
Forebrain
Cranial nerves
7 weeks
Midbrain
Forebrain
Hindbrain
11 weeks
Forebrain
Cerebellum
Medulla
Midbrain (hidden)
At birth

Forebrain

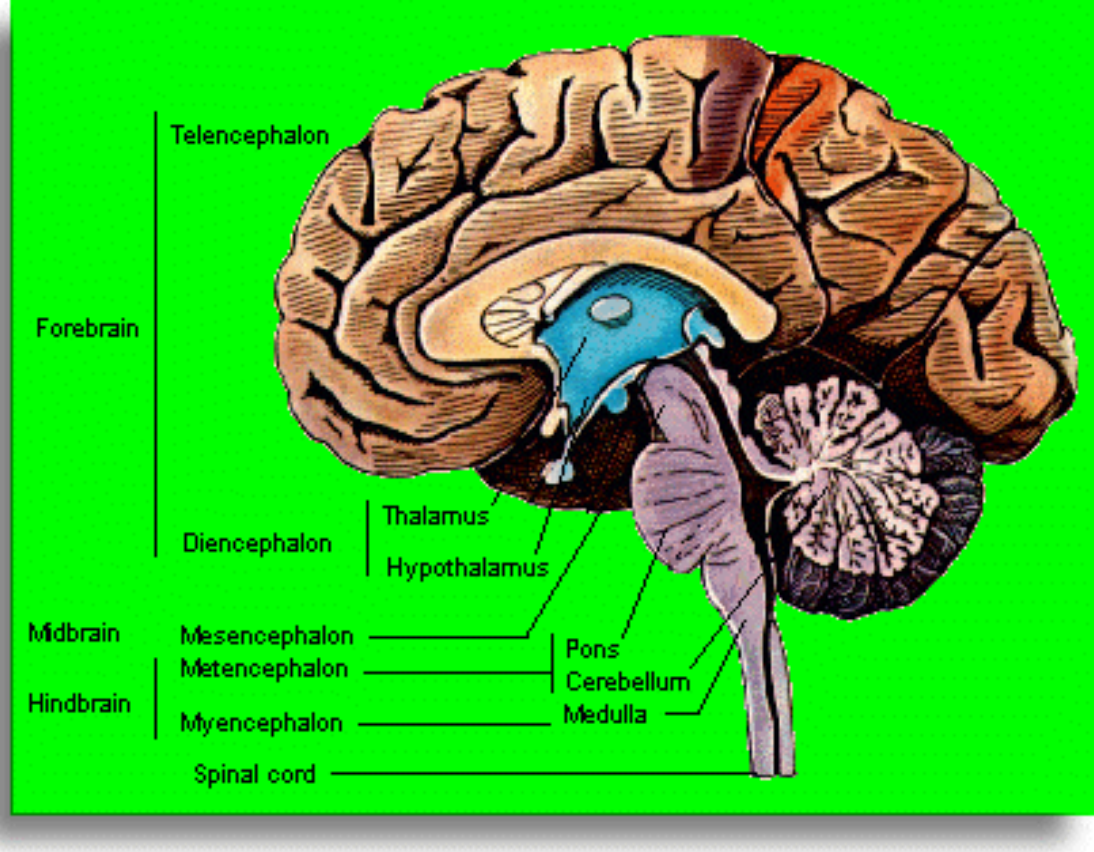


(Prosencephalon)

- telencephalon
  - Cerebral Hemispheres
    - Cerebral Cortex
      Basal ganglia
      Basal forebrain nuclei
      Amygdaloid Nucleus
- diencephalon
  - Thalamus and Hypothalamus



- Midbrain (mesencephalon)
- Hindbrain (rhombencephalon)
  - metencephalon
    - Pons and Cerebellum
  - mylencephalon
    - Medulla Oblongata



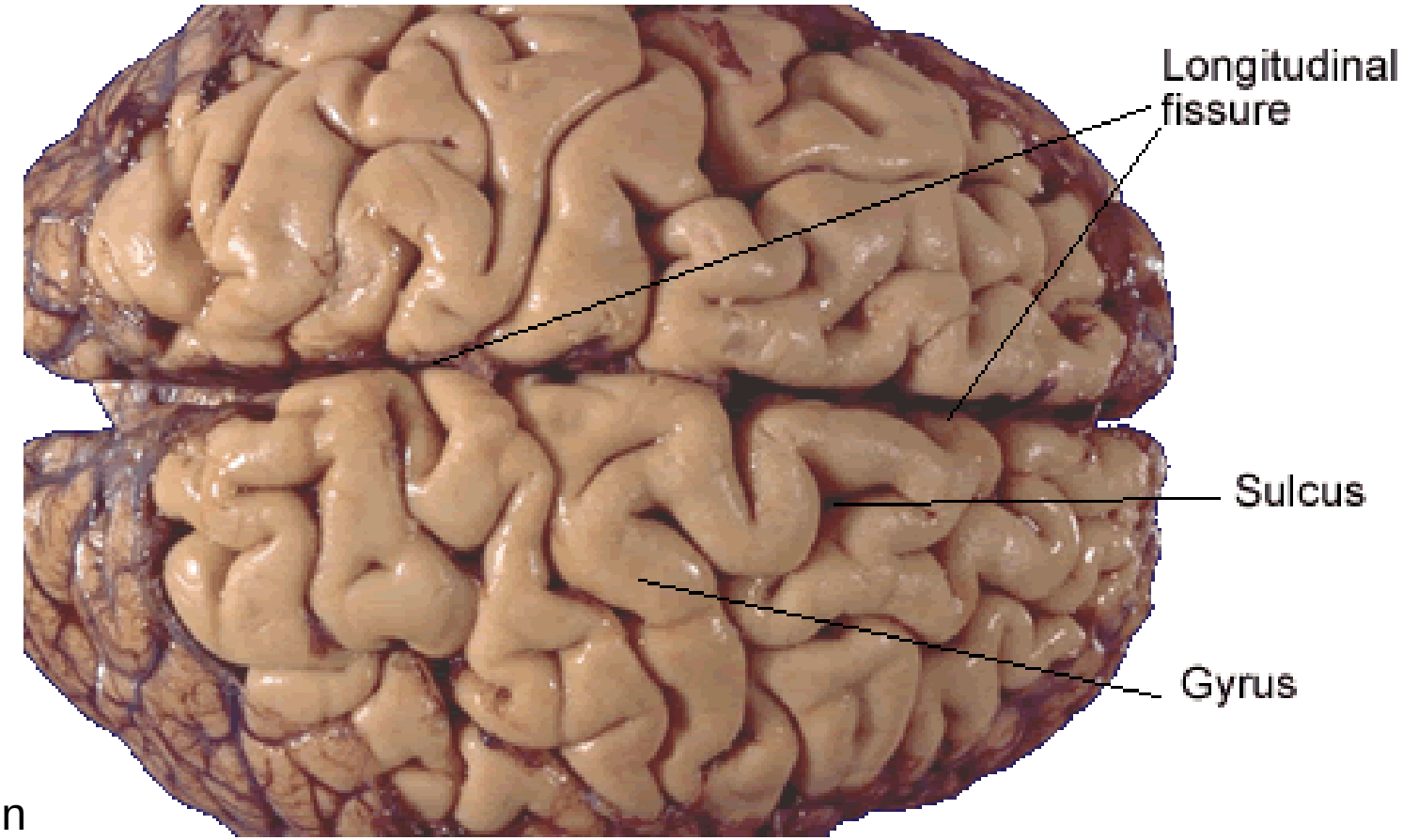
Midbrain (mesencephalon)

- tegmentum-rostral part of the brainstem
- superior colliculus- important for visual system reflexes
- inferior colliculusimportant for auditory system function.
- cerebral peduncle- huge bundle of axons traveling from the cerebral cortex into/ through the brainstem; fibers are important for voluntary motor function.

- red nucleus (not shown) - normal motor function

- substantia nigra (not shown)- normal motor function

Cerebrum

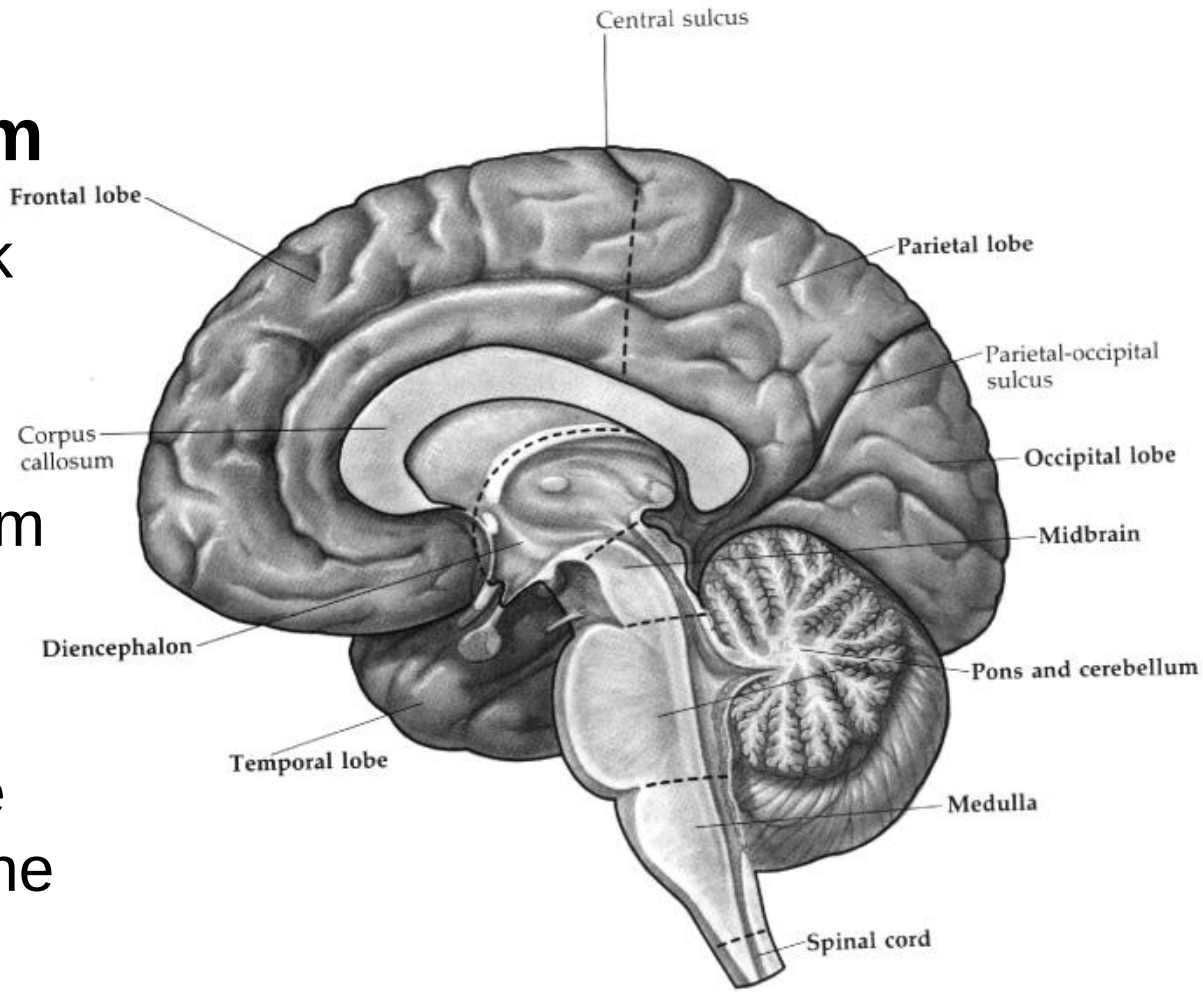


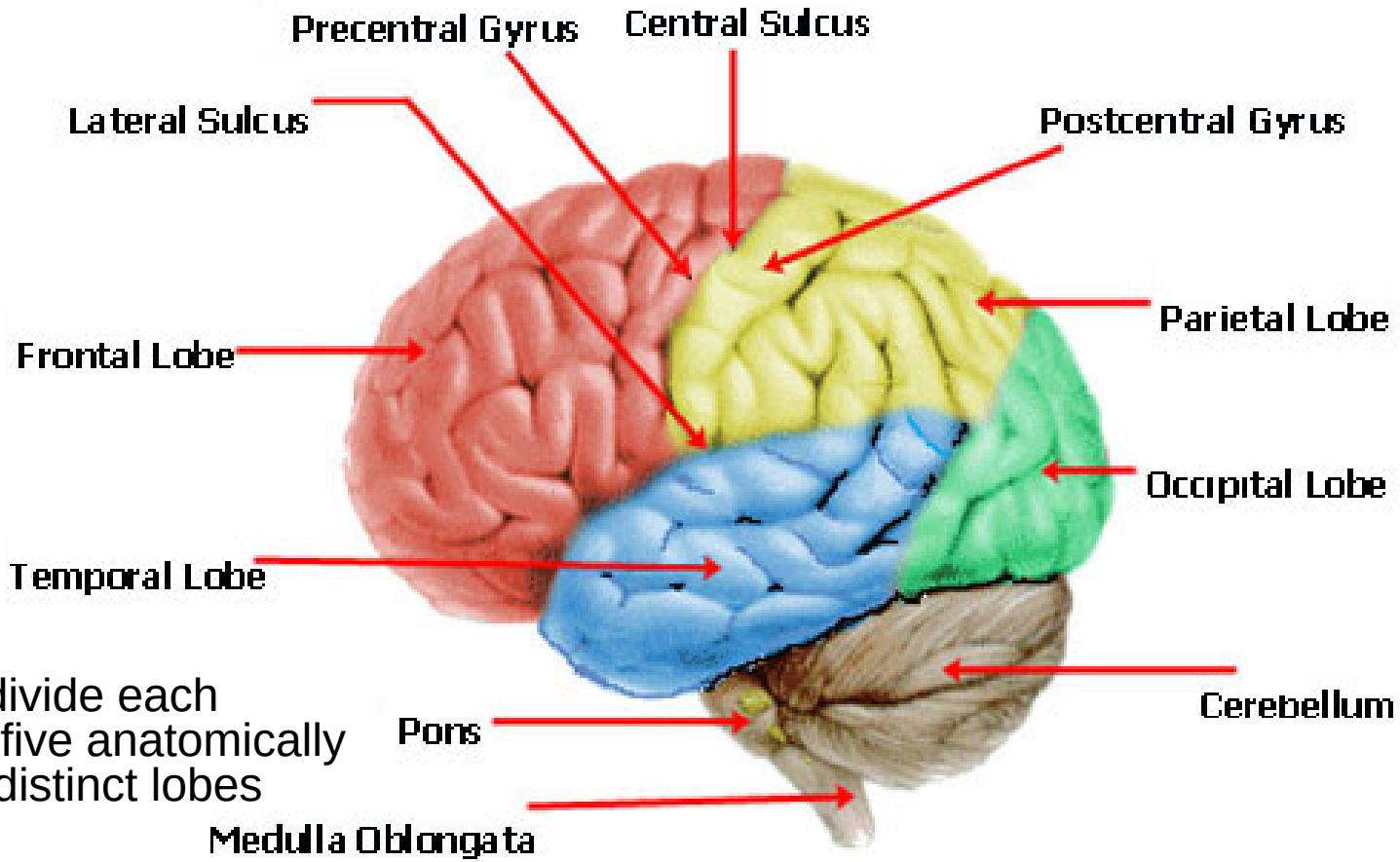
- 83% of brain
  - two hemispheres
    - **Gyri**- thick folds
    - **Sulci**- shallow grooves on the brain surface
    - **longitudinal fissure-** deep grooves that separates hemispheres

Cerebrum

Corpus Callosum

- prominent landmark for anatomical description
- located at the bottom of the longitudinal fissure
- is a bundle of nerve fibers that connect the hemispheres





- prominent sulci divide each hemisphere into five anatomically and functionally distinct lobes
  - frontal
    - **central sulcus-** posterior boundary
  - parietal
    - **parieto-occipital sulcus-** caudal boundary
  - occipital
  - temporal
    - **lateral sulcus-** separate from parietal lobe
  - insula- deep to the lateral sulcus

Cerebral Histology

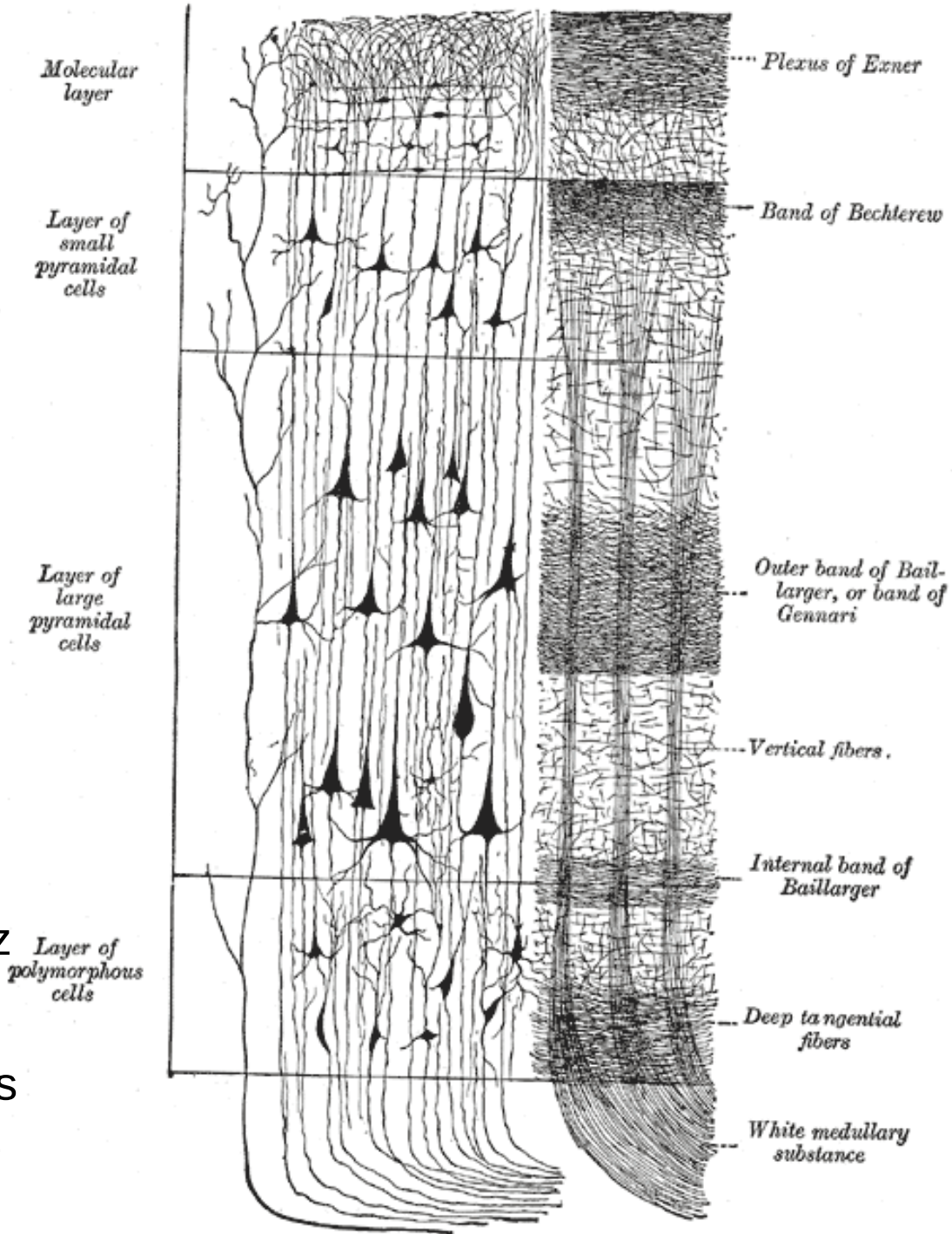
- Cerebral cortex is a 2-3mm thick layer of tissue covering the cerebrum which contains about 40% of the mass of the brain with about 14-16 billion neurons.
- Composed of two principal types of neurons
  - **Stellate cells-** have spherical somas with dendrites projecting for short distances in all directions
    - are concerned with receiving sensory input
  - **Pyramidal cells-** tall and triangular with an apex that points toward the brain surface and has thick dendrite with many branches and small knobby dendritic spines
    - are the output neurons that transport signals to other parts of the CNS

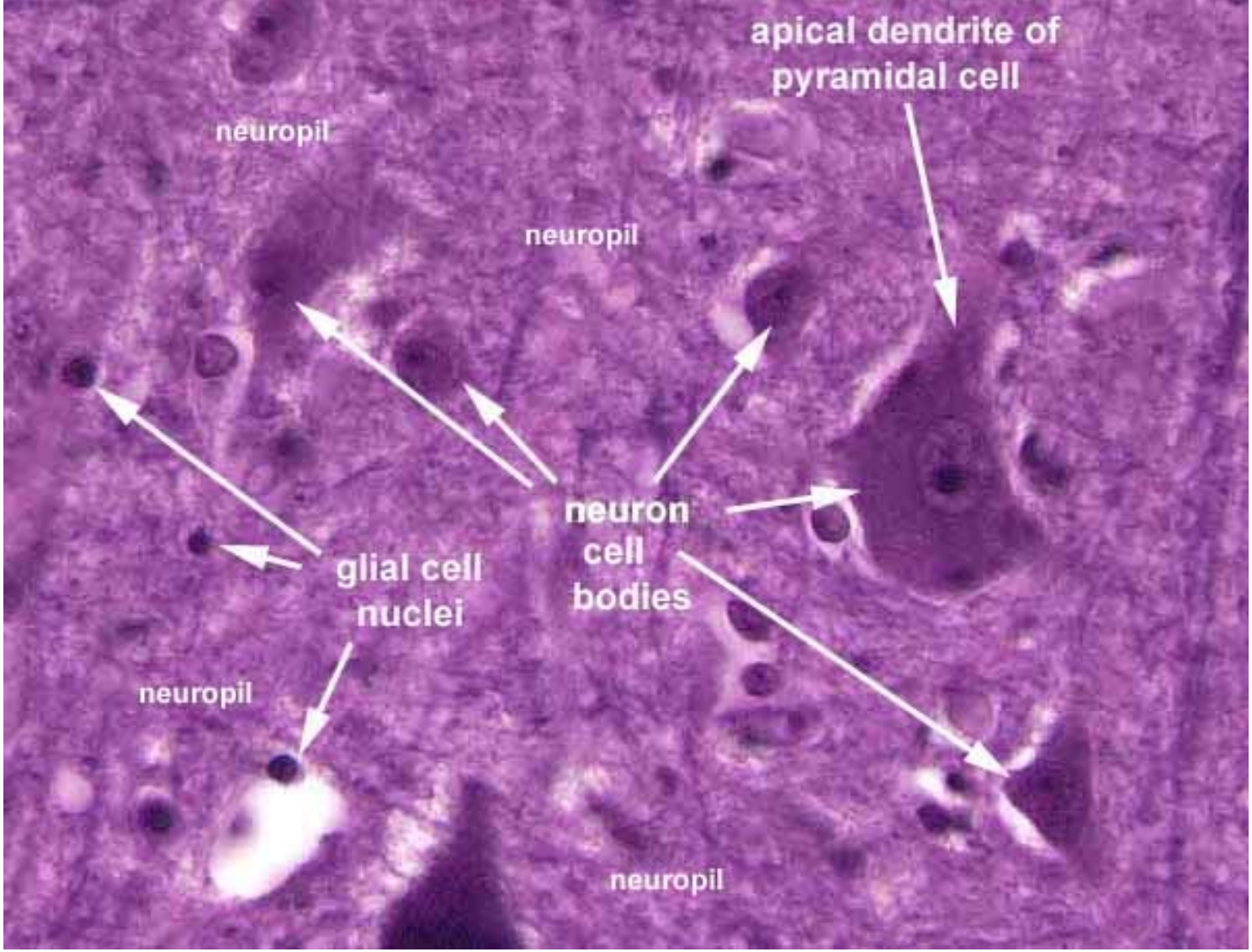
Cerebral Histology

- About 90% of the cerebral cortex is a six layered tissue called the **neocortex** because of it recent evolutionary development.
- The layers are numbered I (outer layer) to VI (most inner layer) and vary from one part of the cerebrum to another in thickness, cellular composition, synaptic connections, size of neurons, and destination of their axons.
  - layer IV is thickest in sensory regions and layer V in motor regions
  - all axons that leave the cortex and enter the white matter arise from layers III, V, and VI.

Cerebral Cortex Histology

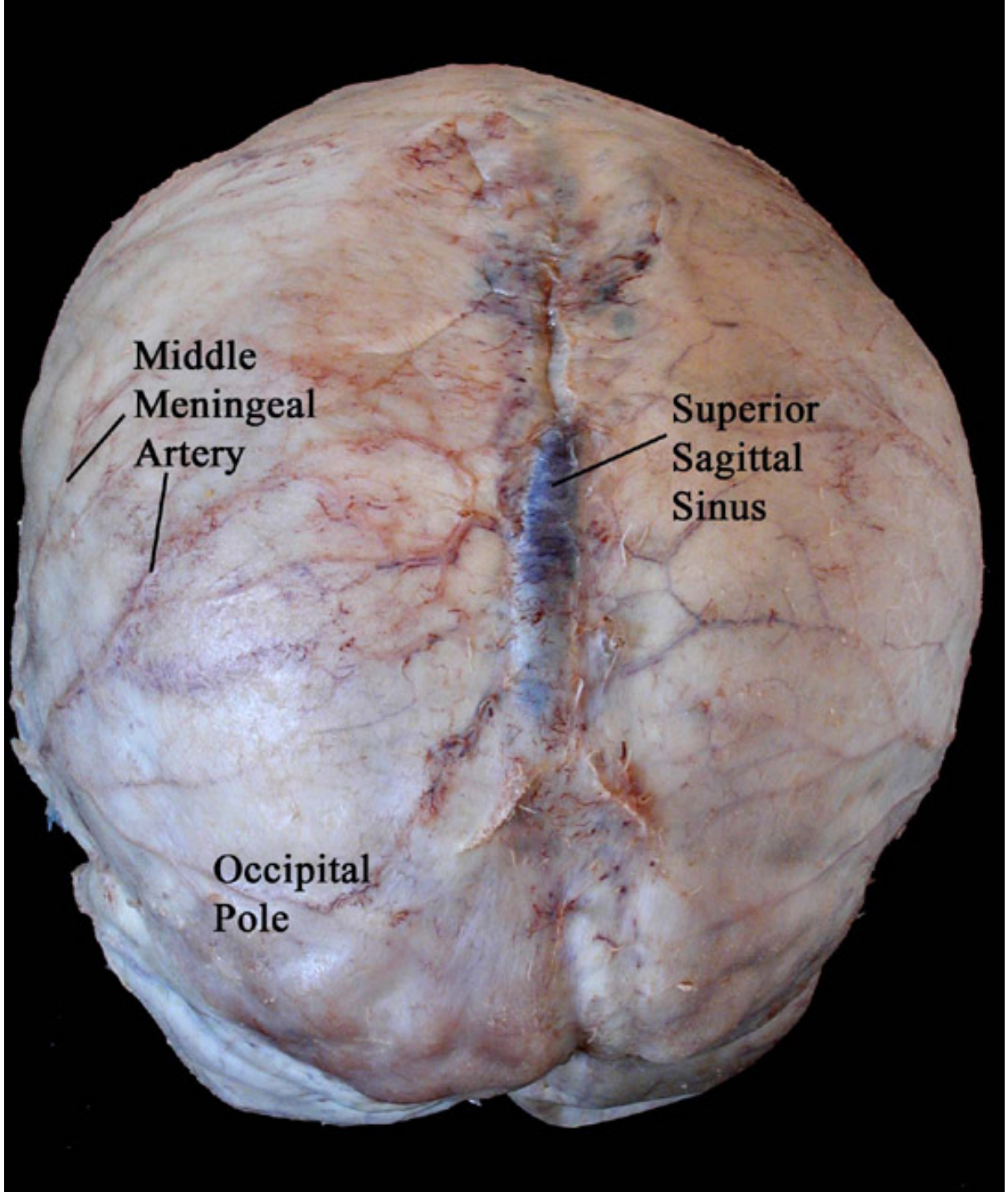
- (1) Plexiform layer (molecular layer)- mostly fibers running parallel to surface, neuroglial cells, and a few horizontal cells of Cajal
- (2) Outer granular cell layer; small pyramidal cells (stellate cells)
- (3) a layer of medium pyramidal cells
- (4) Inner granular layer; many small granule cells (stellate cells)
- (5) Large pyramidal cells (Betz cells)
- (6) a layer of polymorphic cells- cells with diverse shapes (fusiform cells)

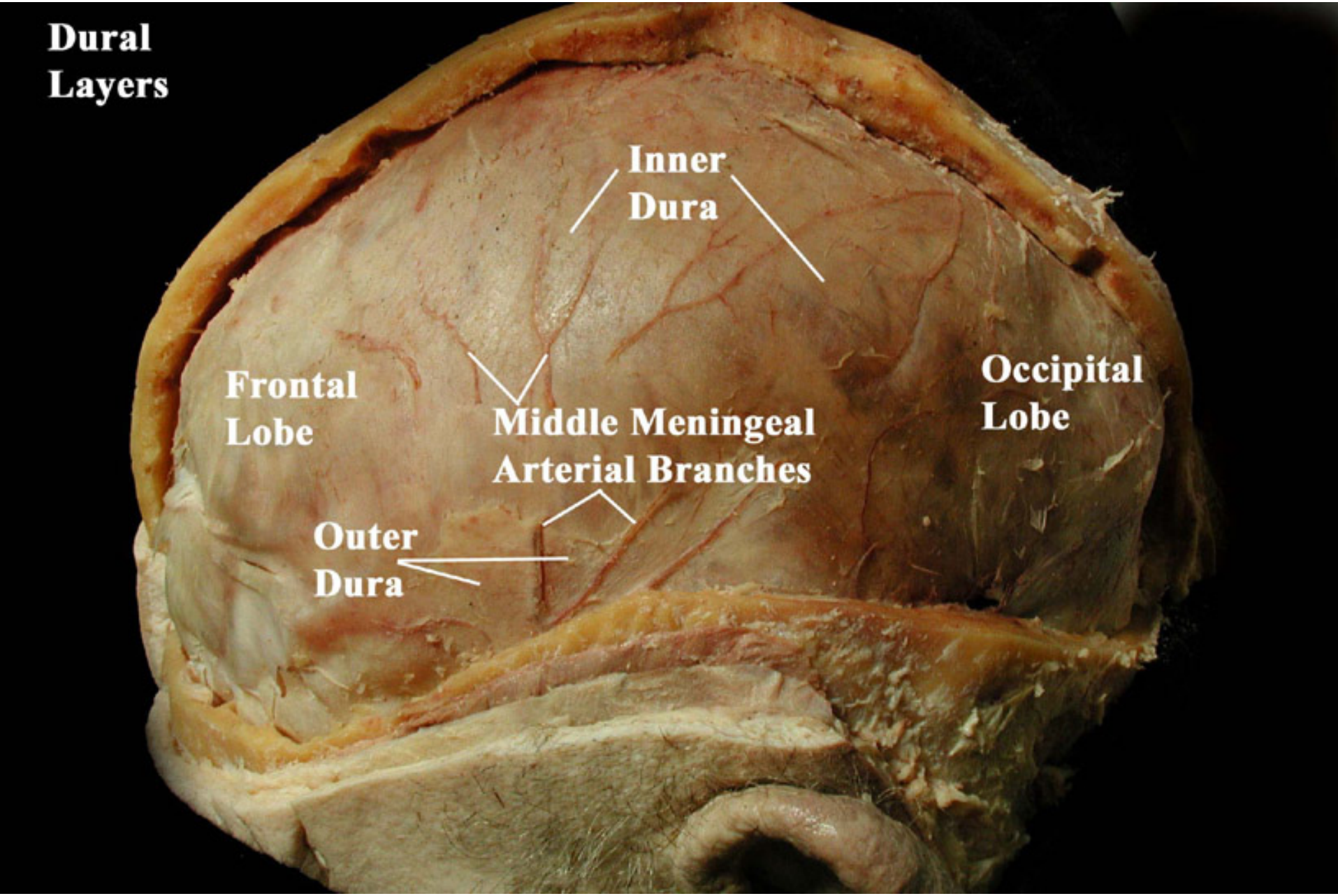


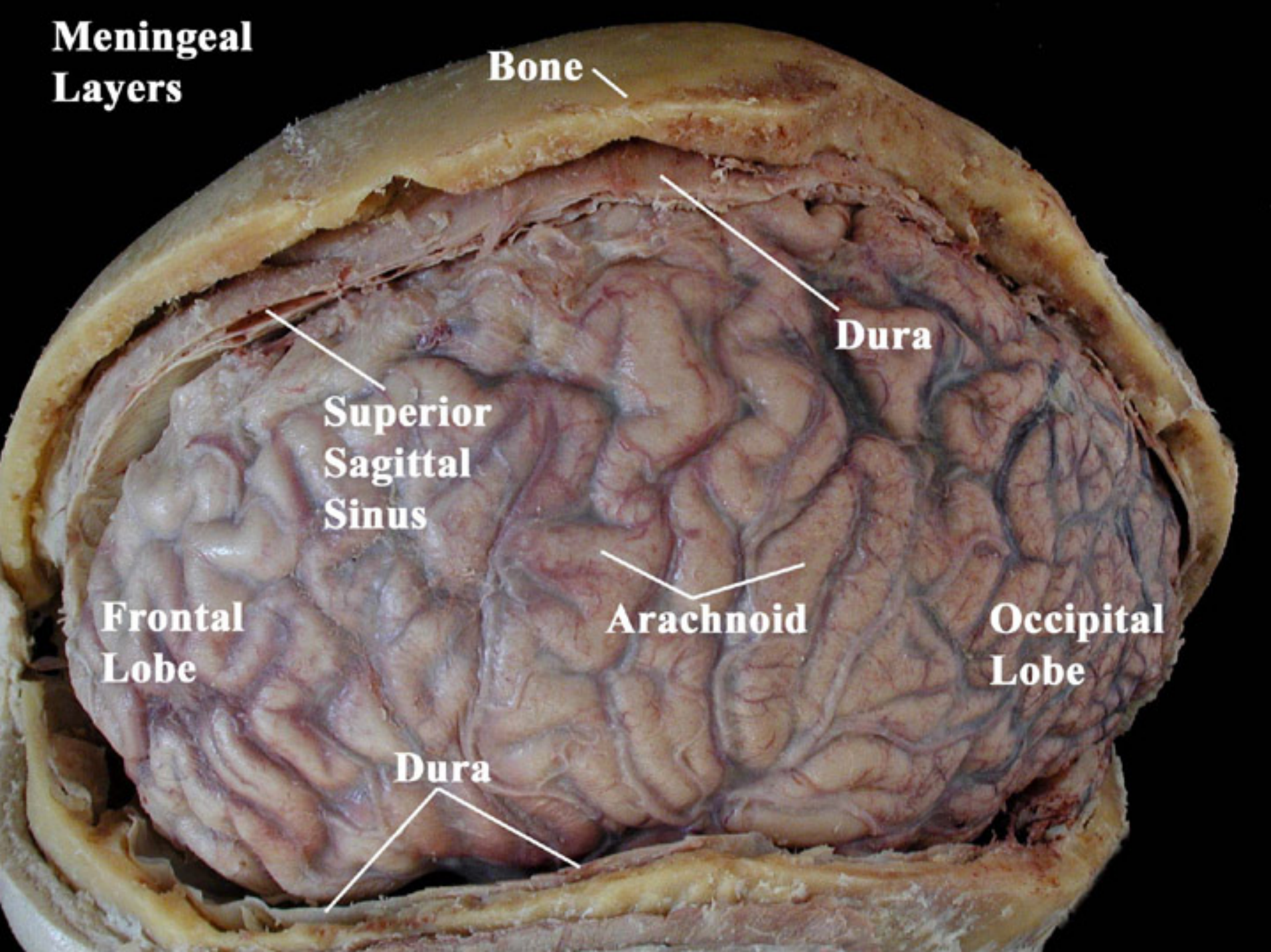


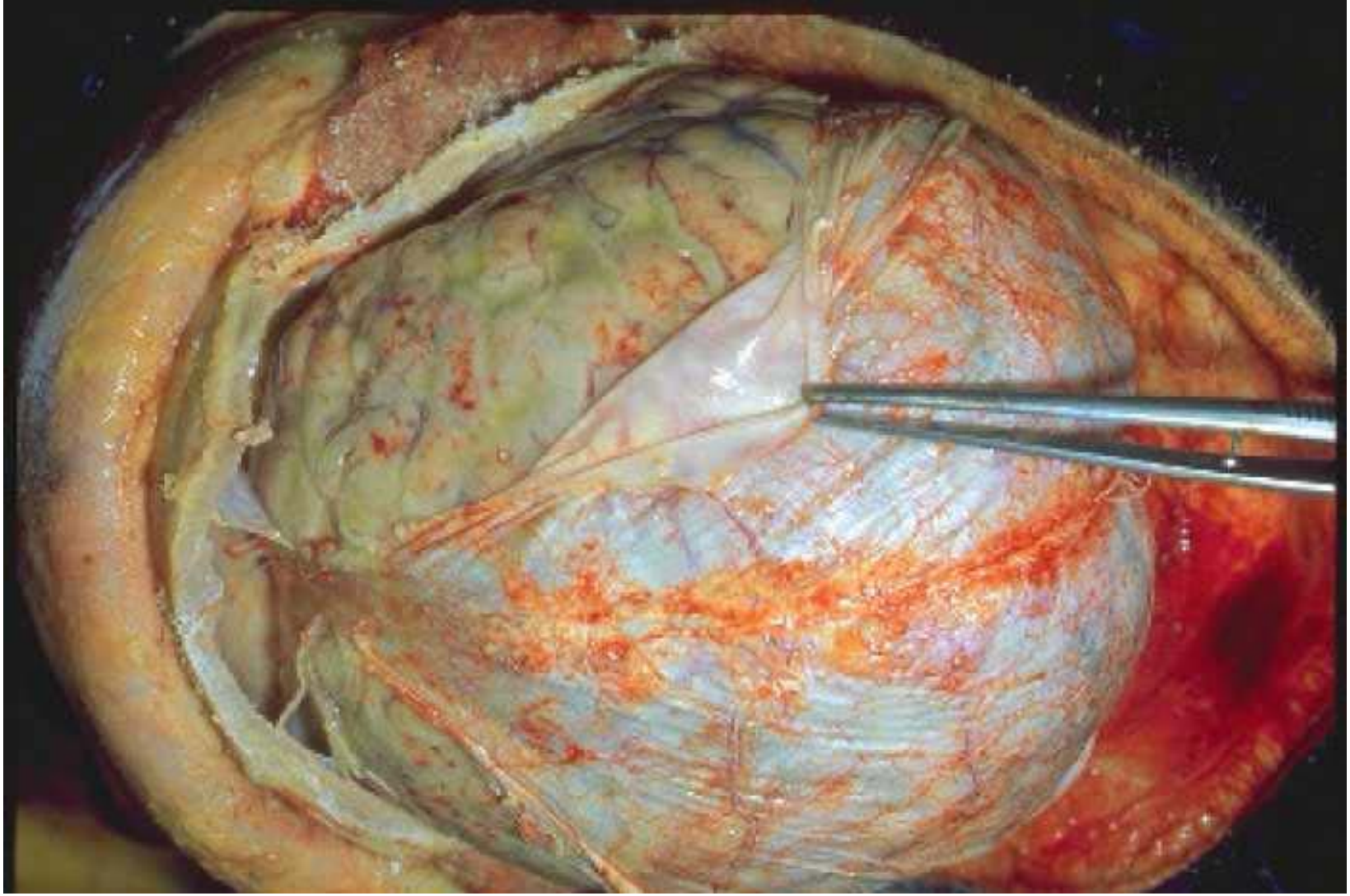
Pyramidal cells-

- **recognized by their relatively large somata and by their prominent apical dendrites (i.e., the upward "apex" on the "pyramid").**
  - **"owl-eye" or "fried-egg" nuclei.**
- The giant **Betz cells** are extremely large pyramidal cells of the **motor (precentral) cortex**.


Middle
Meningeal
Artery
Superior
Sagittal
Sinus
Occipital
Pole

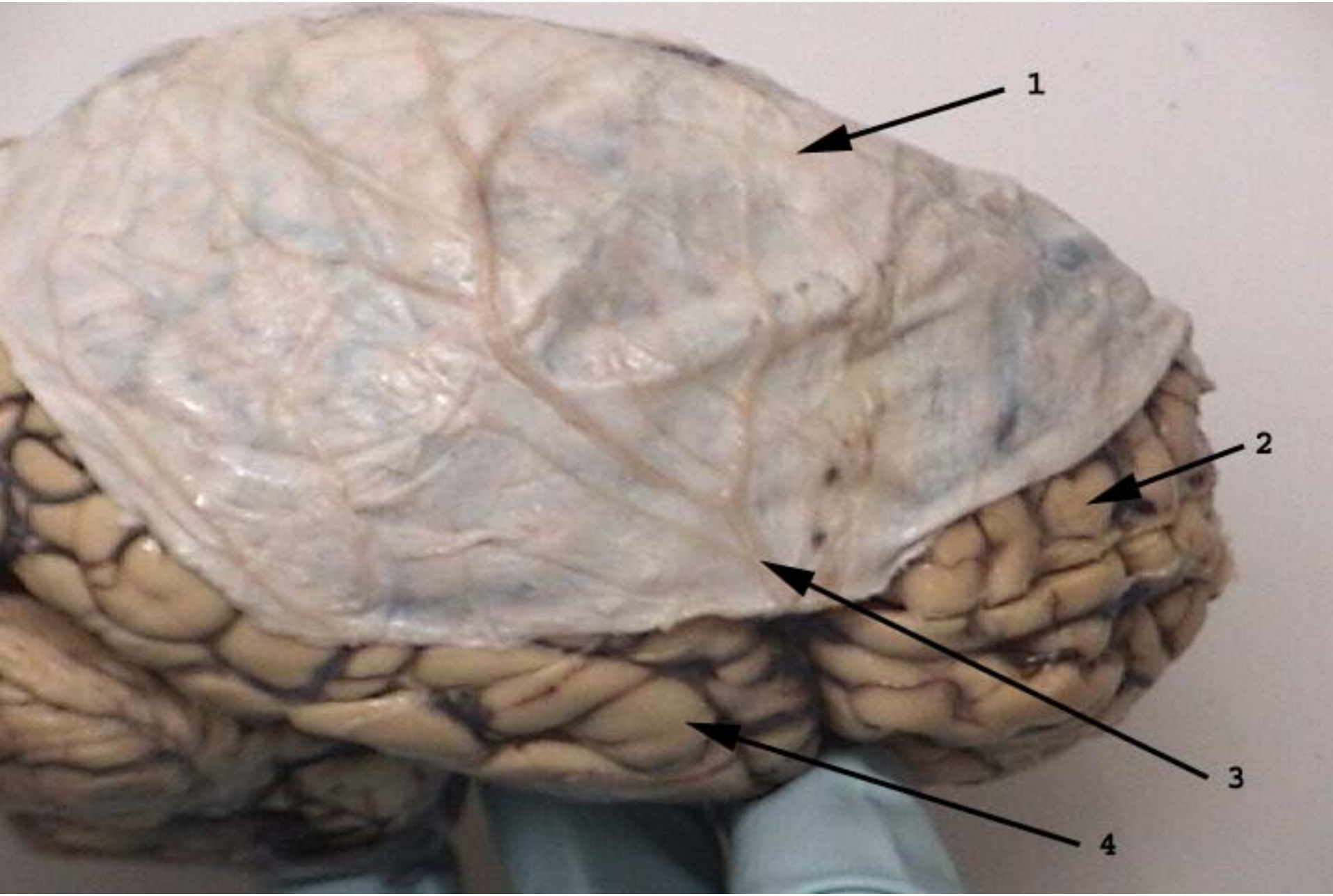

Dural
Layers
Inner
Dura
Frontal
Lobe
Middle Meningeal
Arterial Branches
Occipital
Lobe
Outer
Dura

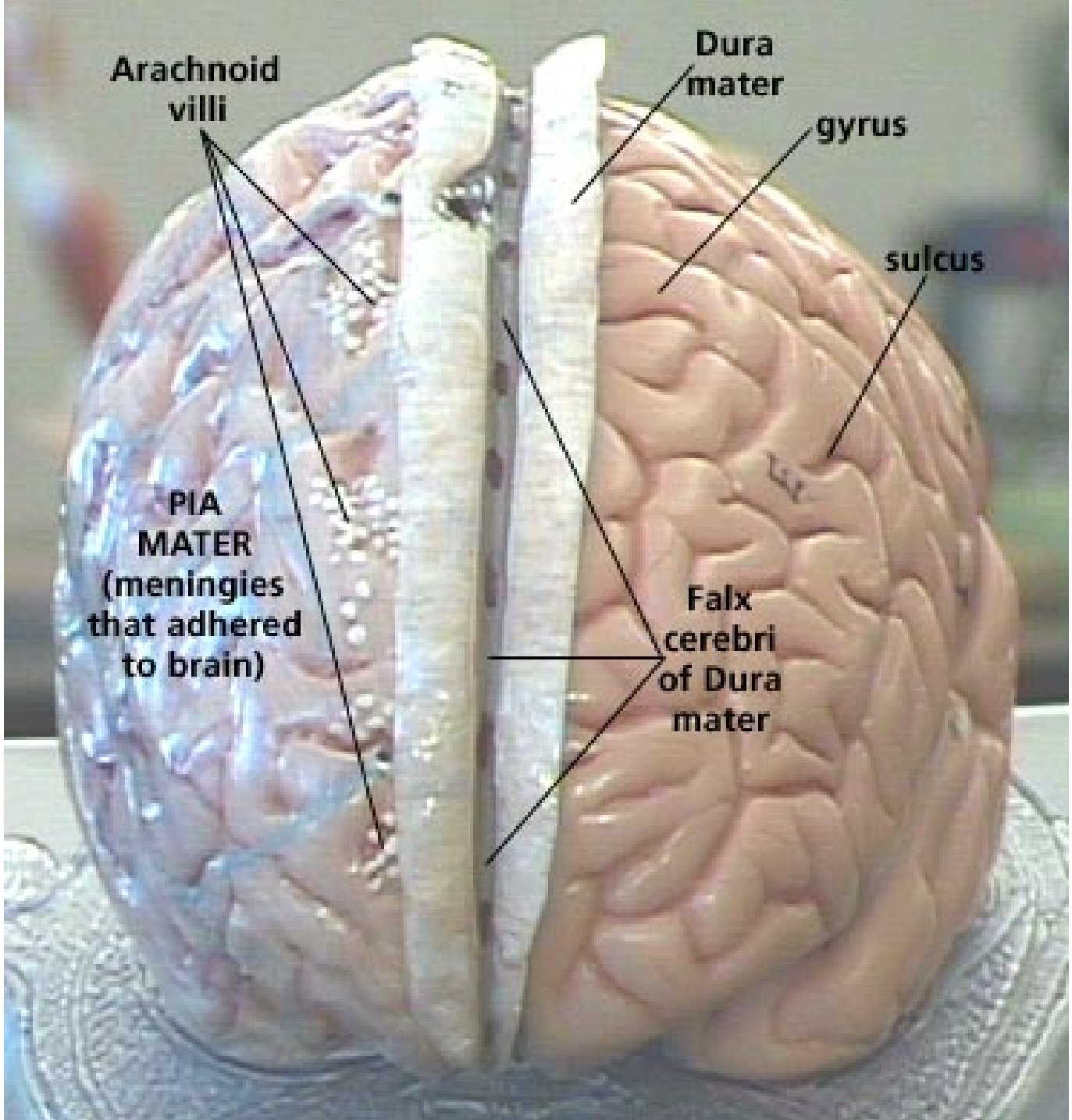

Meningeal Layers
Bone
Dura
Superior Sagittal Sinus
Frontal Lobe
Arachnoid
Occipital Lobe
Dura

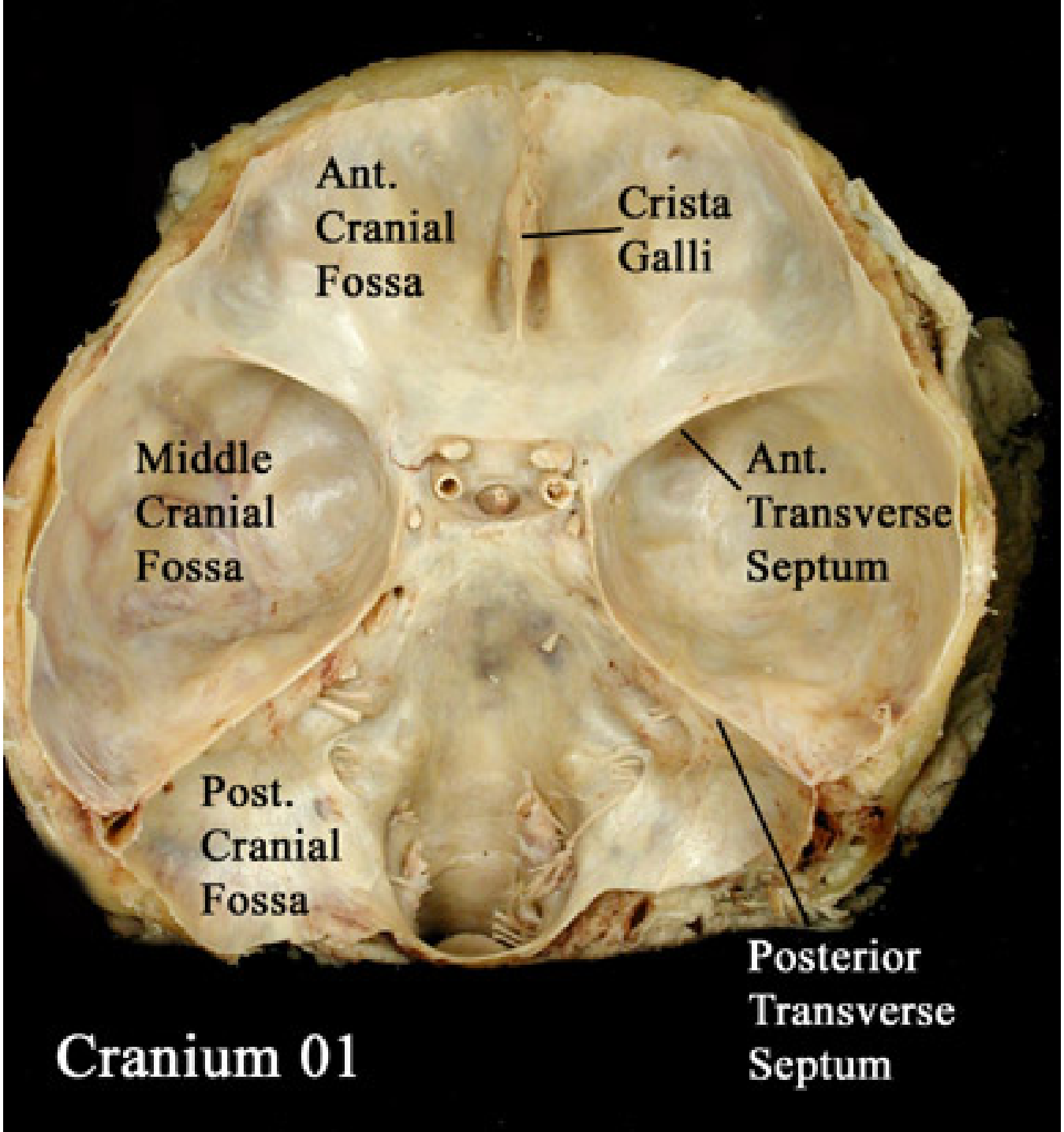


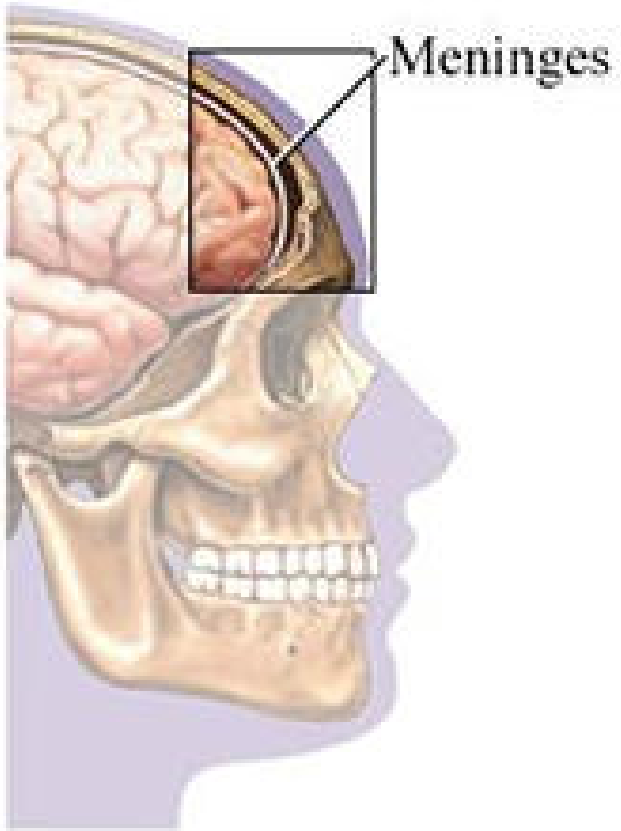
Meninges

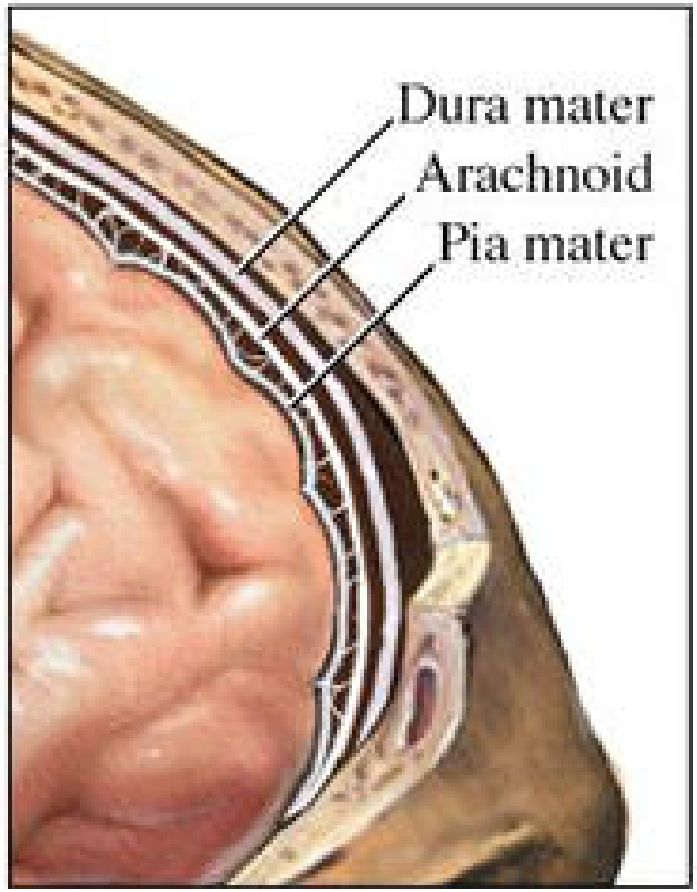
(three fibrous membranes that enclose the brain and spinal cord)


1
2
3
4


Arachnoid villi
Dura mater
gyrus
sulcus
PIA MATER (meningies that adhered to brain)
Falx cerebri of Dura mater


Ant.
Cranial
Fossa
Crista
Galli
Middle
Cranial
Fossa
Ant.
Transverse
Septum
Post.
Cranial
Fossa
Posterior
Transverse
Septum
Cranium 01



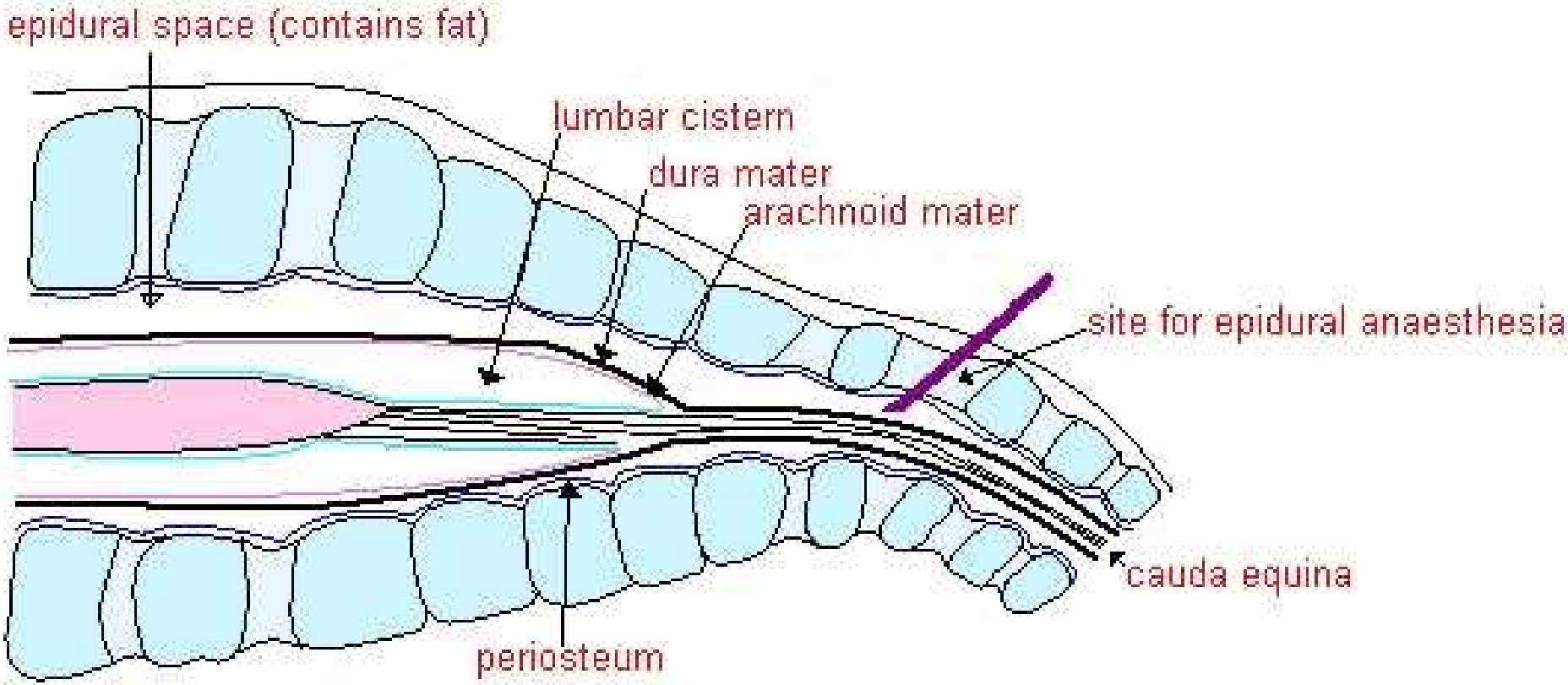


- Same as those of the spinal cord
  - dura mater (pachymeninx)
    - composed of relatively avascular connective tissue.
    - there are two major dural folds in the cranium:
      - FALX CEREBRI - a fold lying in the longitudinal fissure between the cerebral hemispheres.
      - TENTORIUM CEREBELLI - a horizontal fold separating the cerebral hemispheres from the cerebellum.
  - arachnoid mater
  - pia mater

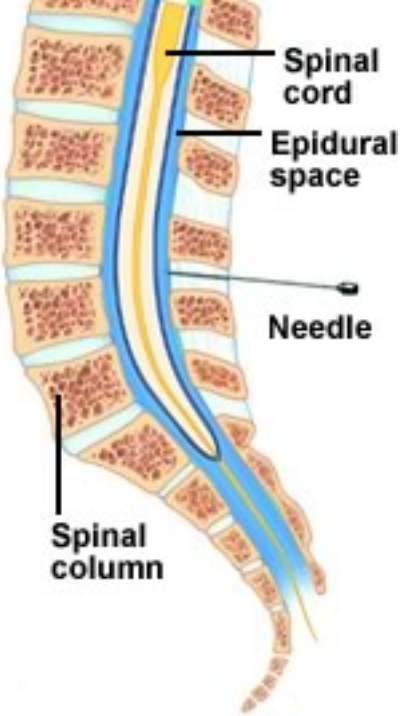
Dura Mater

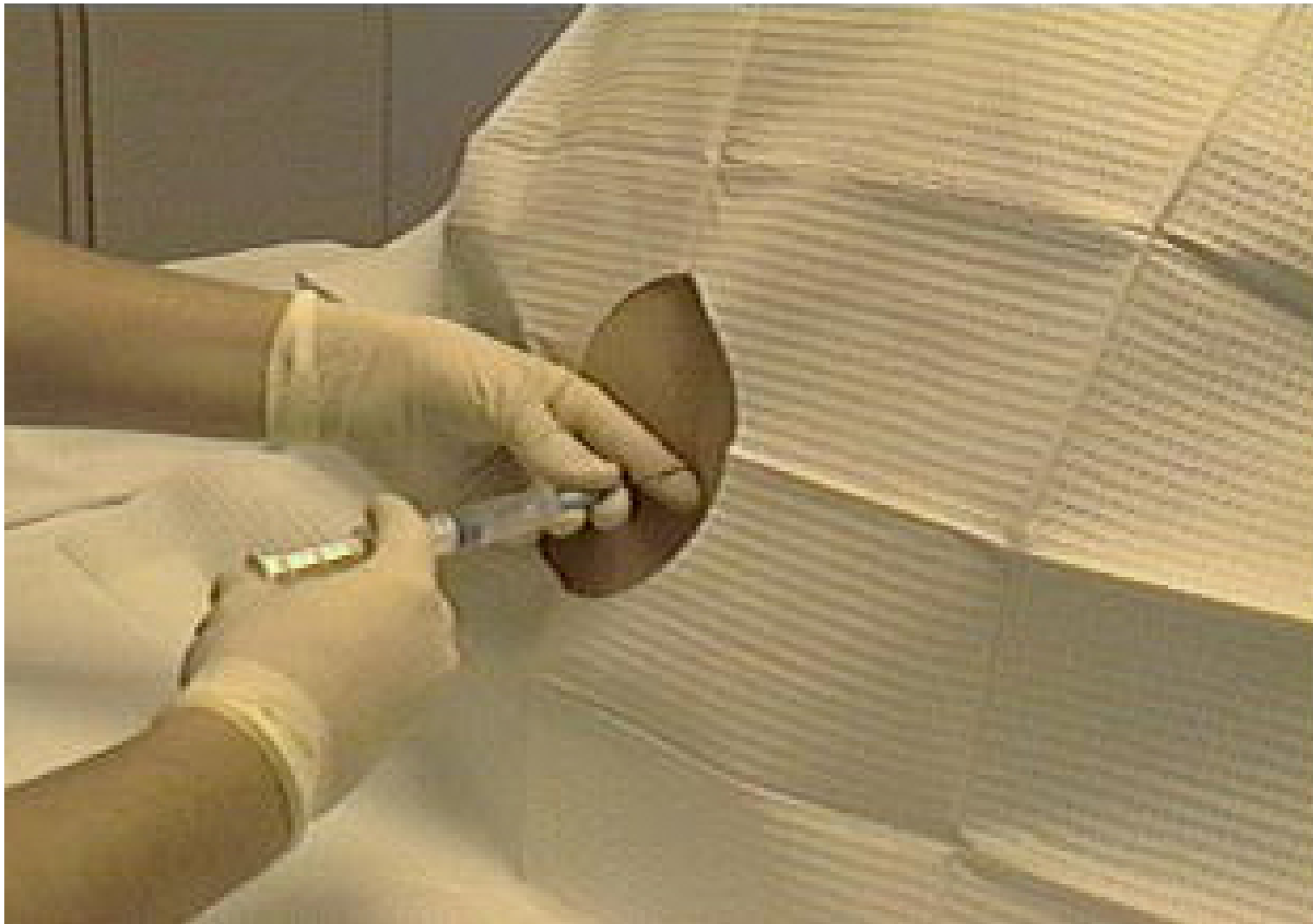
- Composed of relatively avascular connective tissue.
- There are two major dural folds in the cranium:
  - **FALX CEREBRI -** a fold lying in the longitudinal fissure between the cerebral hemispheres.
  - **TENTORIUM CEREBELLI -** a horizontal fold separating the cerebral hemispheres from the cerebellum.
- has a protective function
  - it prevents shuddering movements of the brain within the cranial cavity and the folds prevent damage to nervous tissue during sudden rotational movements.
- In the **cranial cavity** the dura adheres to the periosteum lining the cranium, so there is **no EPIDURAL SPACE**, except at the venous sinuses.
- In the vertebral canal, the spinal dura is separated from the periosteum of the vertebrae by a space containing epidural fat and the veins which drain the spinal cord.

Injection of local anaesthetic



Epidural





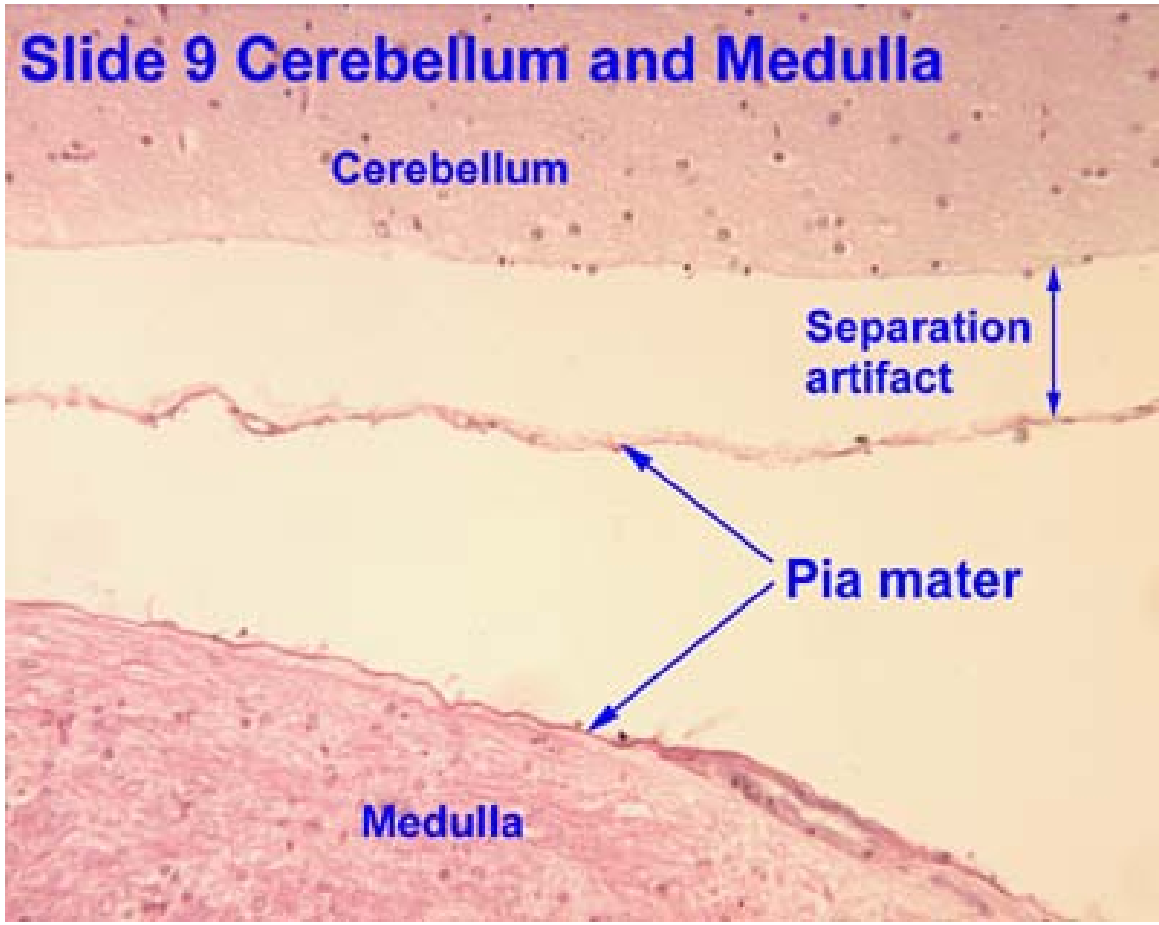
Epidural

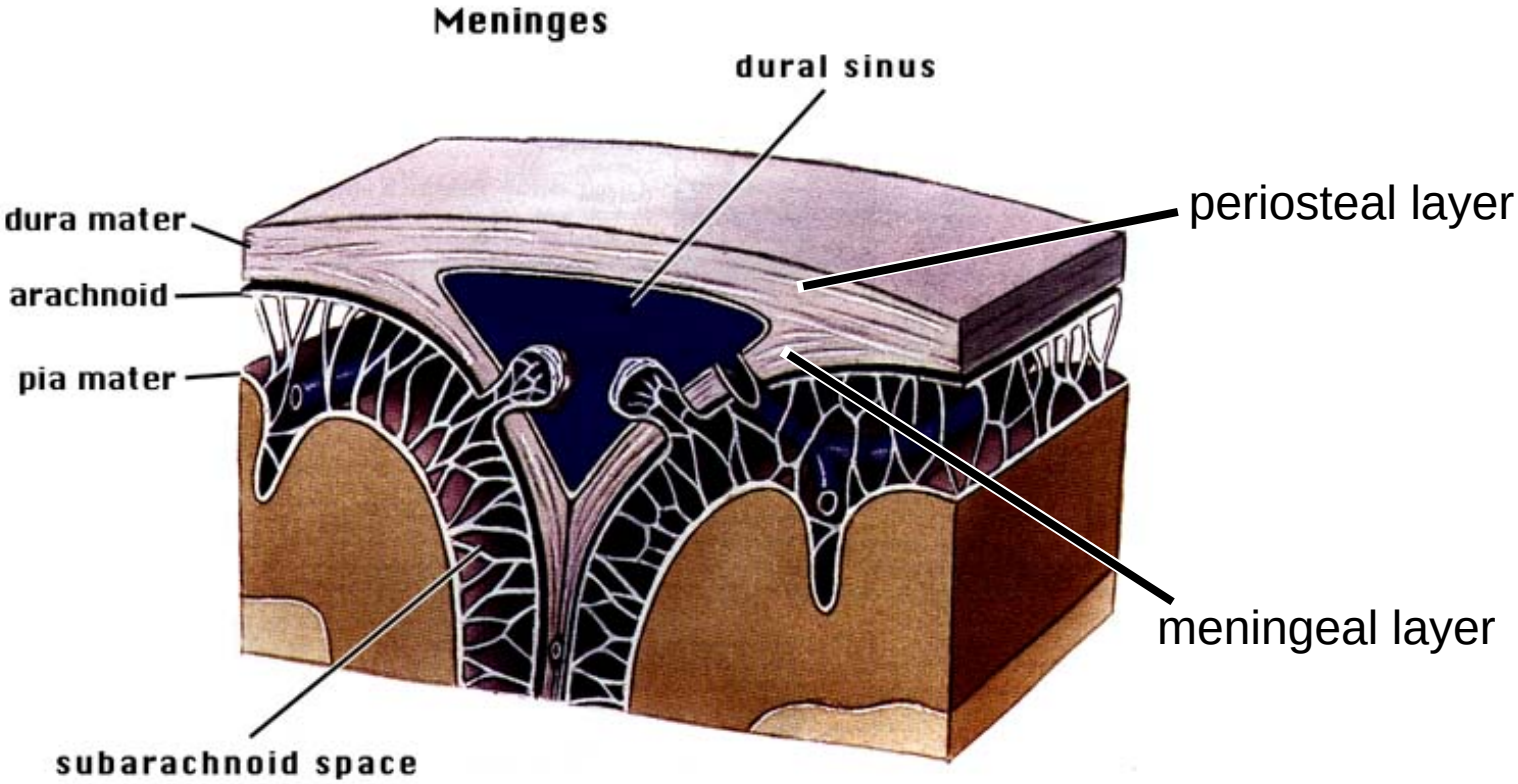
Arachnoid Mater

- Internal to the dura mater
- Is an avascular membrane
- Lies between the pia mater internally and the dura mater externally
- It is separated from the pia mater by the subarachnoid cavity or space, which is filled with cerebrospinal fluid.
- Called arachnoid because the cobweblike trabeculae crossing the subarachnoid spave to become continuous with the pia mater.

Pia Mater

- A delicate translucent membrane that closely contours the spinal cord and brain
- Acts as a floor and anchor for the blood vessels that travel over the surface of the brain





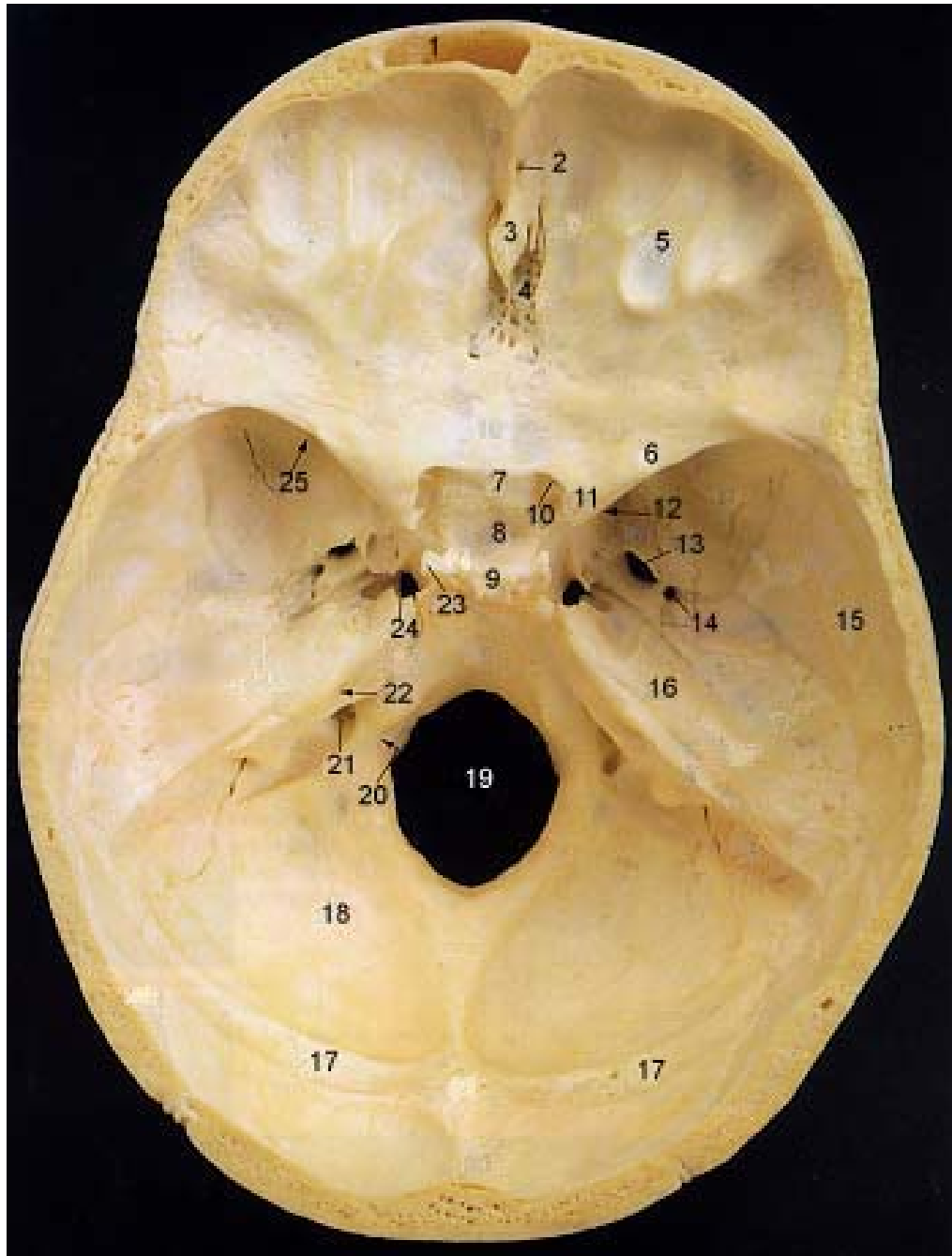
- **the dura** in the cranial cavity consist of two layer
  - **periosteal layer-** equivalent to the periosteum of the cranial bone, lies close to the bone with no epidural space
  - **meningial layer-** continues into the vertebral column
- the two layers are separated in places by the **dural sinuses** (spaces that collect blood that has circulated through the brain)

- In certain places, the meningeal layer of the dura mater folds inward to separate major parts of the brain
  - **falx cerebre-** extends into the longitudinal fissure between the right and left cerebral hemispheres
  - **tentorium cerebelli-** stretches like a roof over the posterior cranial fossa and separates the cerebellum from the overlying cerebrum

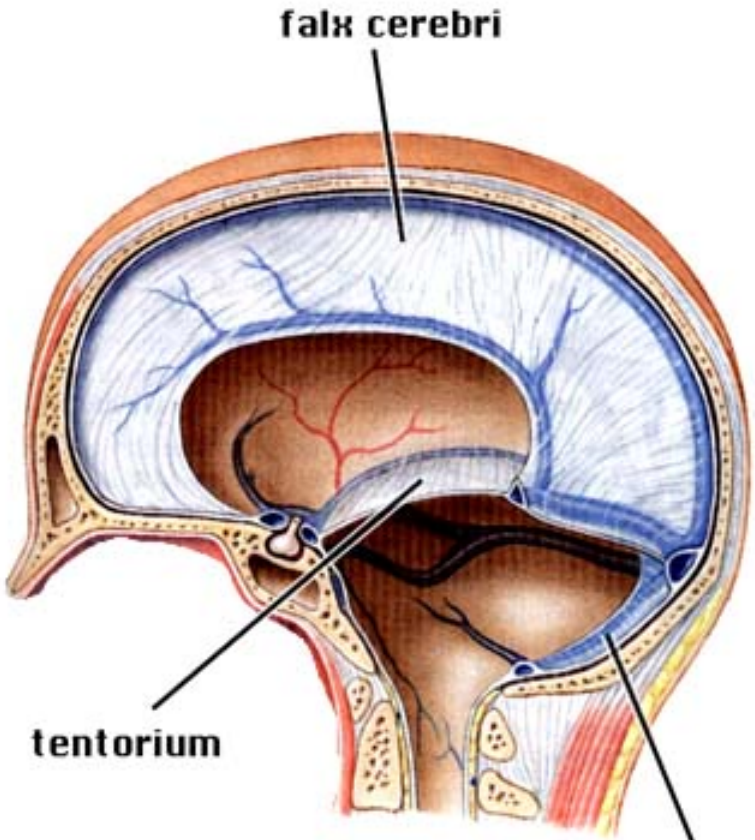
Remember

Cranial Cavities

- Anterior cranial fossa
- Middle cranial fossa
- Posterior cranial fossa

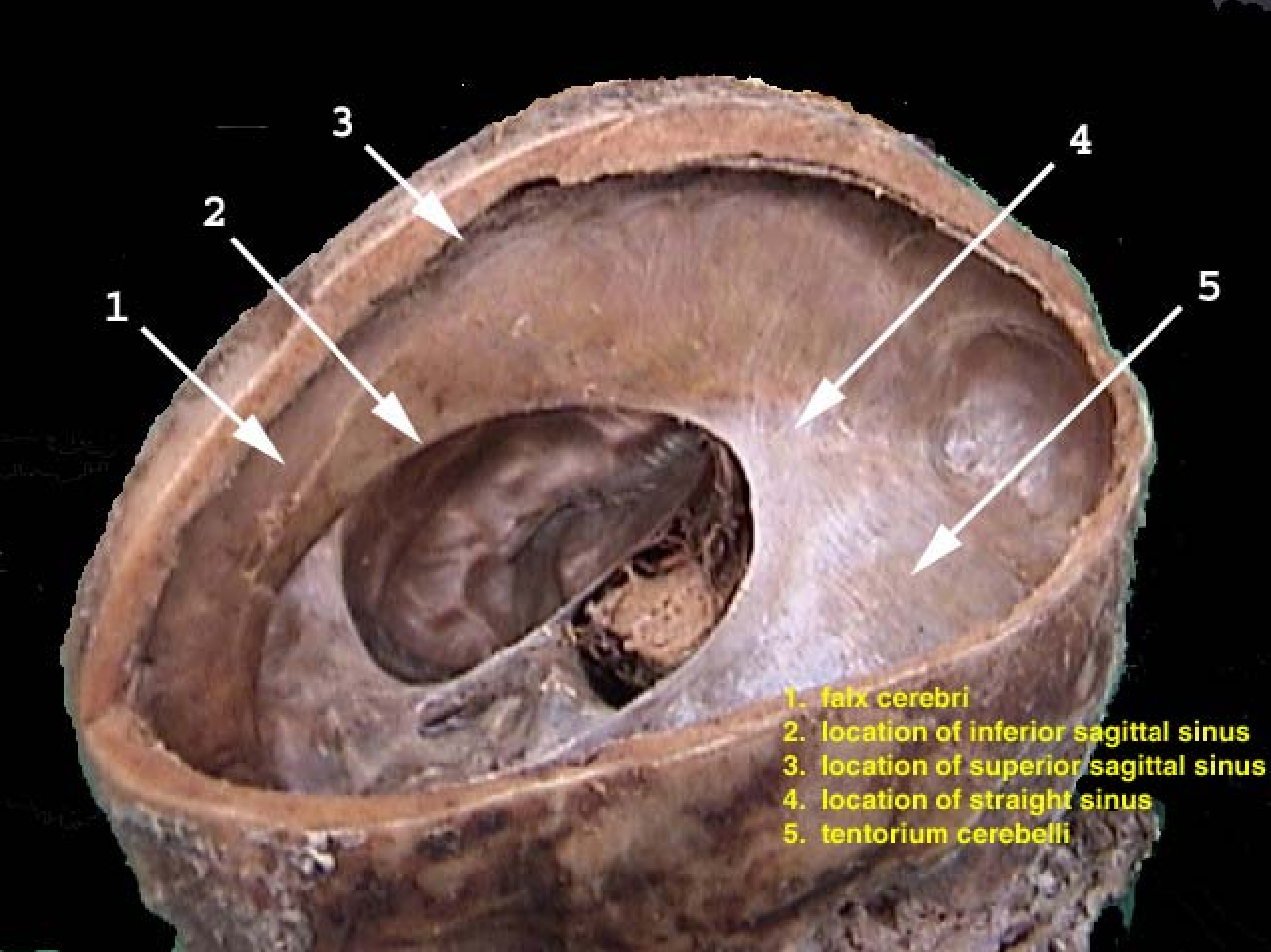


Partitions formed by the Dura Mater



Note the dural sinuses which appear as blue vessels inside the dura mater.

Modified from: Prentice Hall, Martini/Timmons 1997


1
2
3
4
5
1. falx cerebri
2. location of inferior sagittal sinus
3. location of superior sagittal sinus
4. location of straight sinus
5. tentorium cerebelli

Flax Cerebri

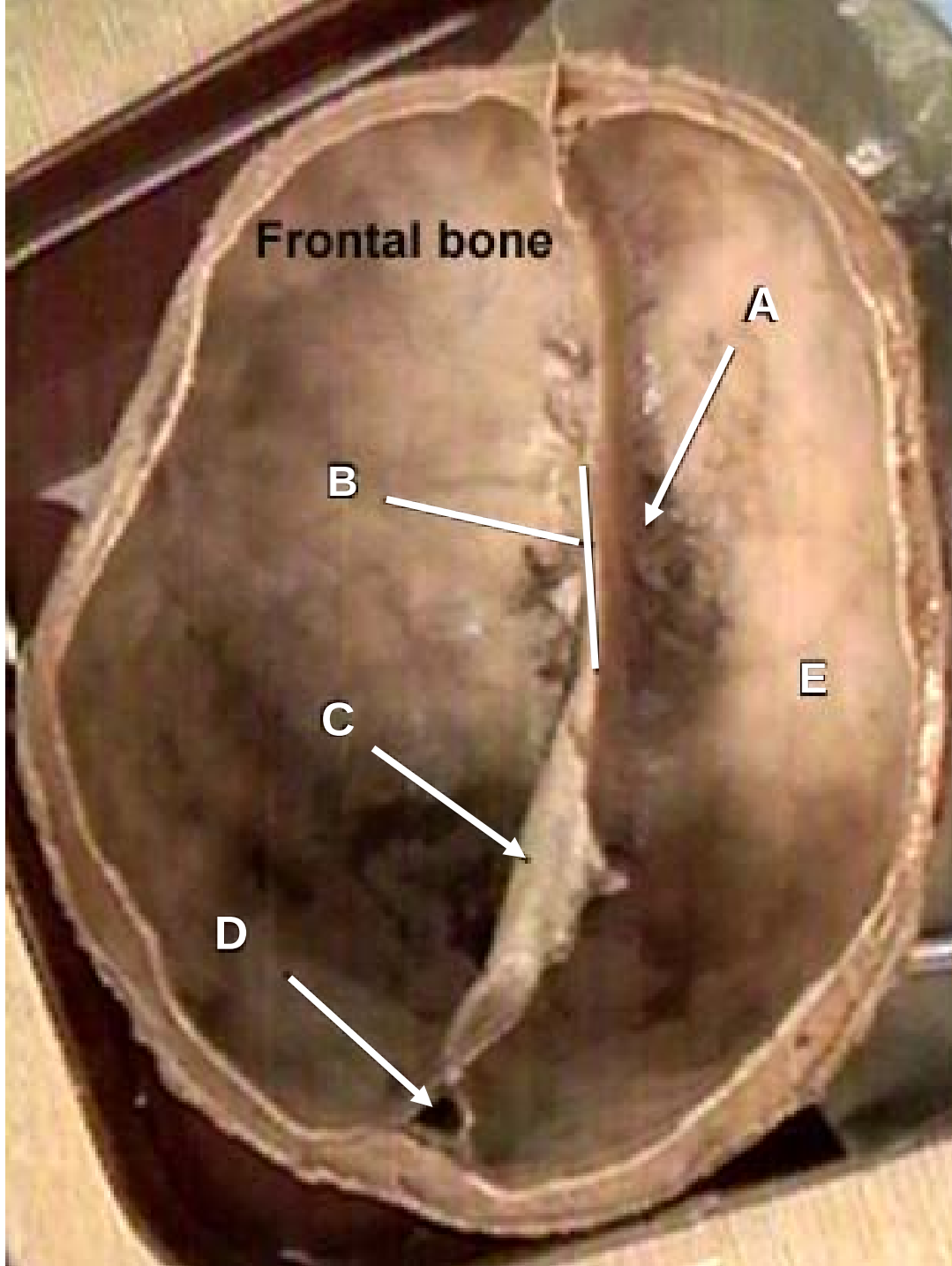
A. Superior sagittal sinus

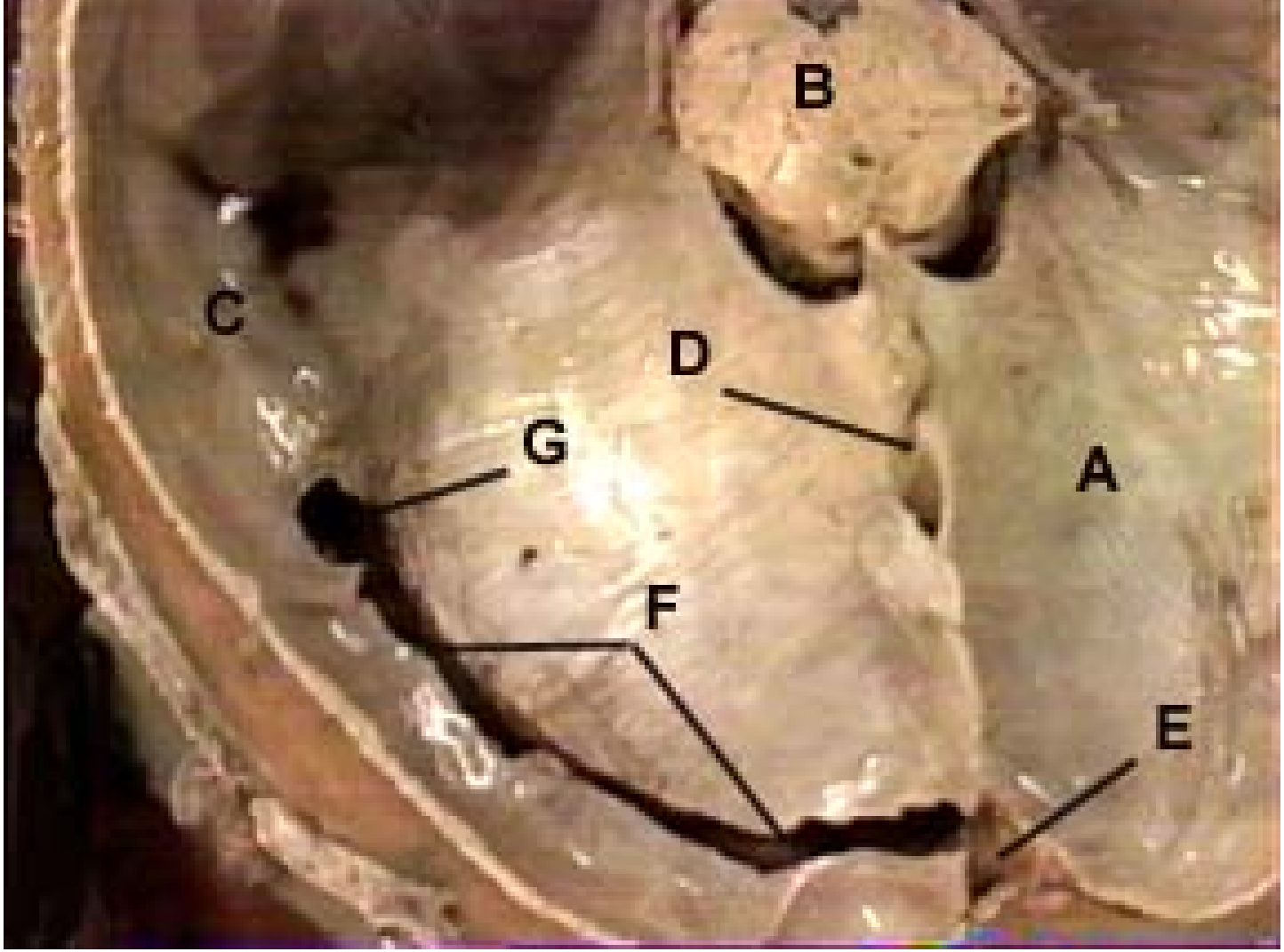
B. Inferior sagittal sinus

C. Falx cerebri (dual fold)

D. Confluence of sinuses

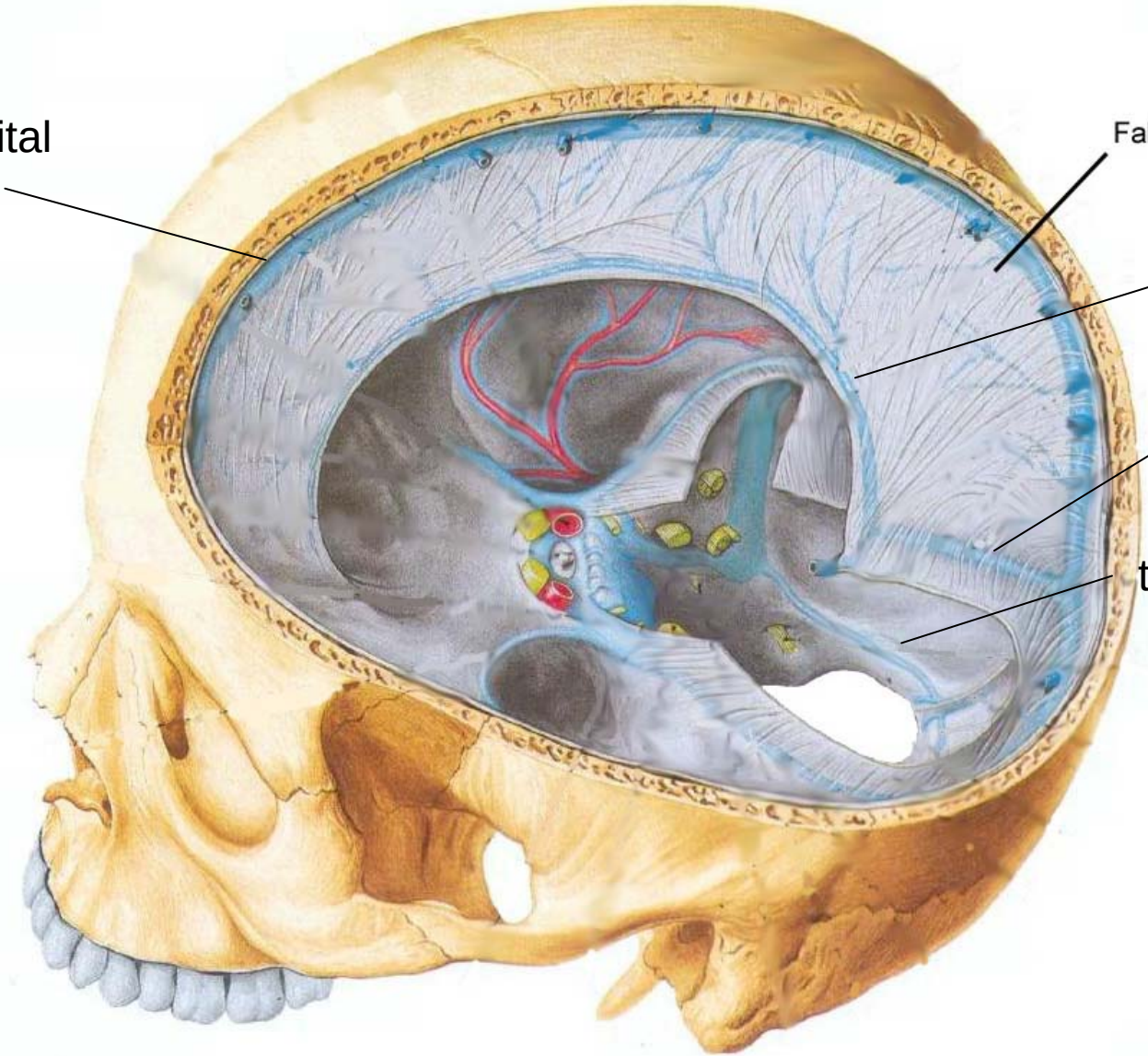
E. Dura mater (meningeal layer)



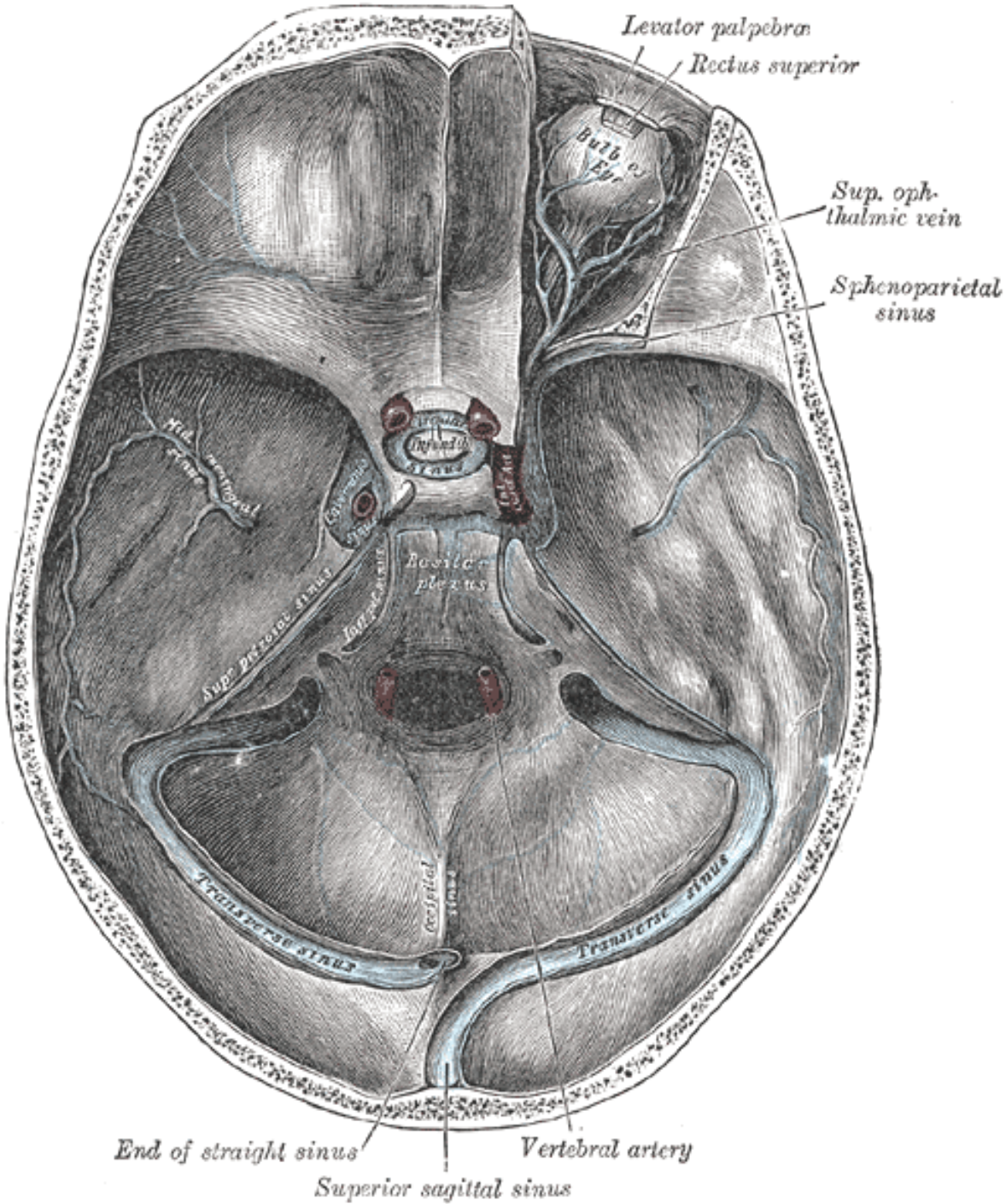


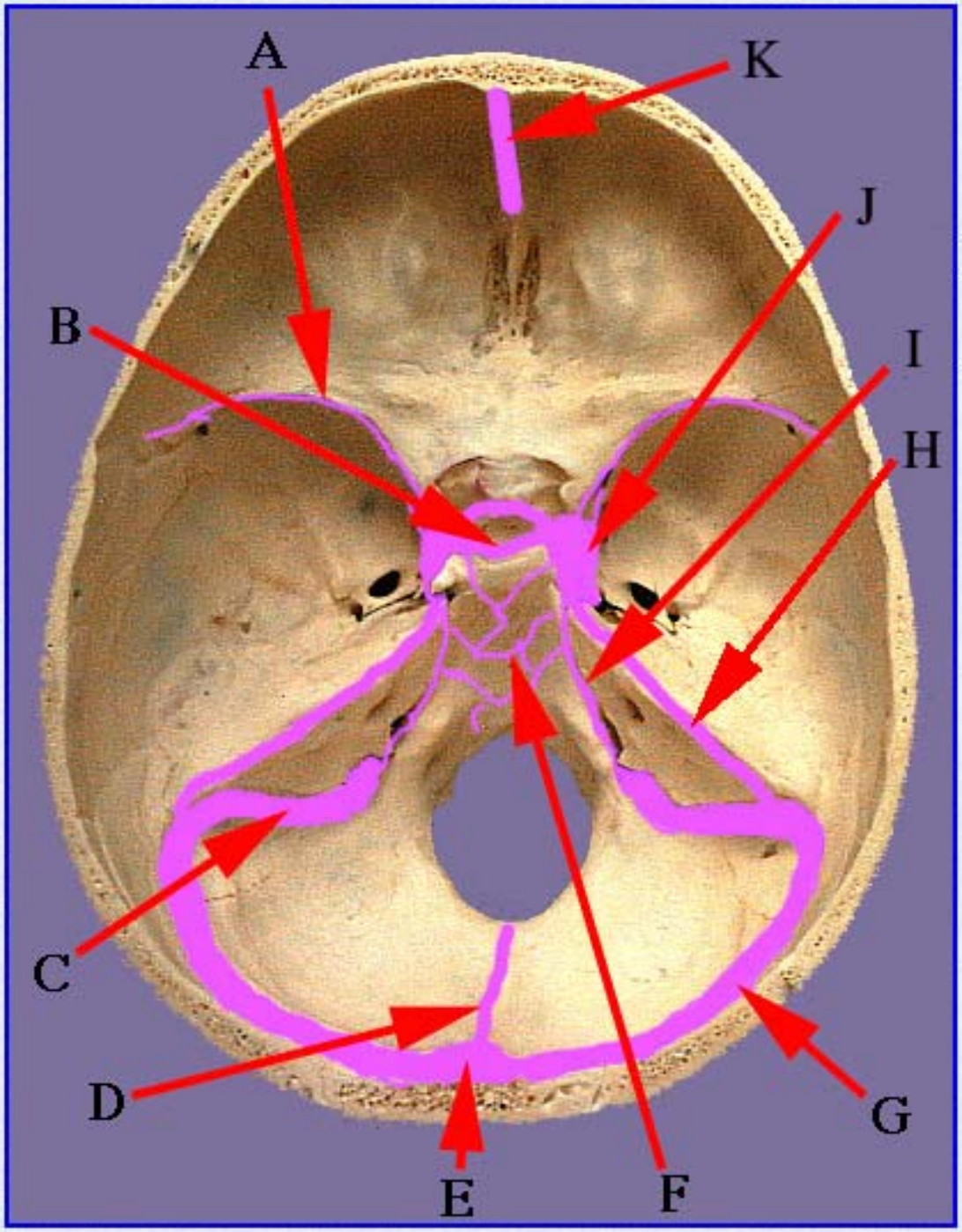
A. Tentorium cerebelli B. Midbrain tegmentum C. Temporal bone(Petrous part) D. Inferior sagittal sinus E. Confluence of sinuses F. Transverse sinus G. Sigmoid sinus

.



- The separations of the two layers of the dura mater create the **dural venous sinuses.** The venous sinuses receive the blood from the veins draining the brain, and this blood flows from the venous sinuses to the internal jugular veins. The walls of the sinuses are line by endothelium.


Levator palpebræ
Rectus superior
Sup. ophthalmic vein
Sphenoparietal sinus
End of straight sinus
Superior sagittal sinus
Vertebral artery



J. Cavernous

K. Superior Sagittal

Dural Venous Sinuses.

A. Sphenoparietal

B. Intercavernous

C. Sigmoid

D. Occipital

E. Confluence

F. Basilar

G. Transverse

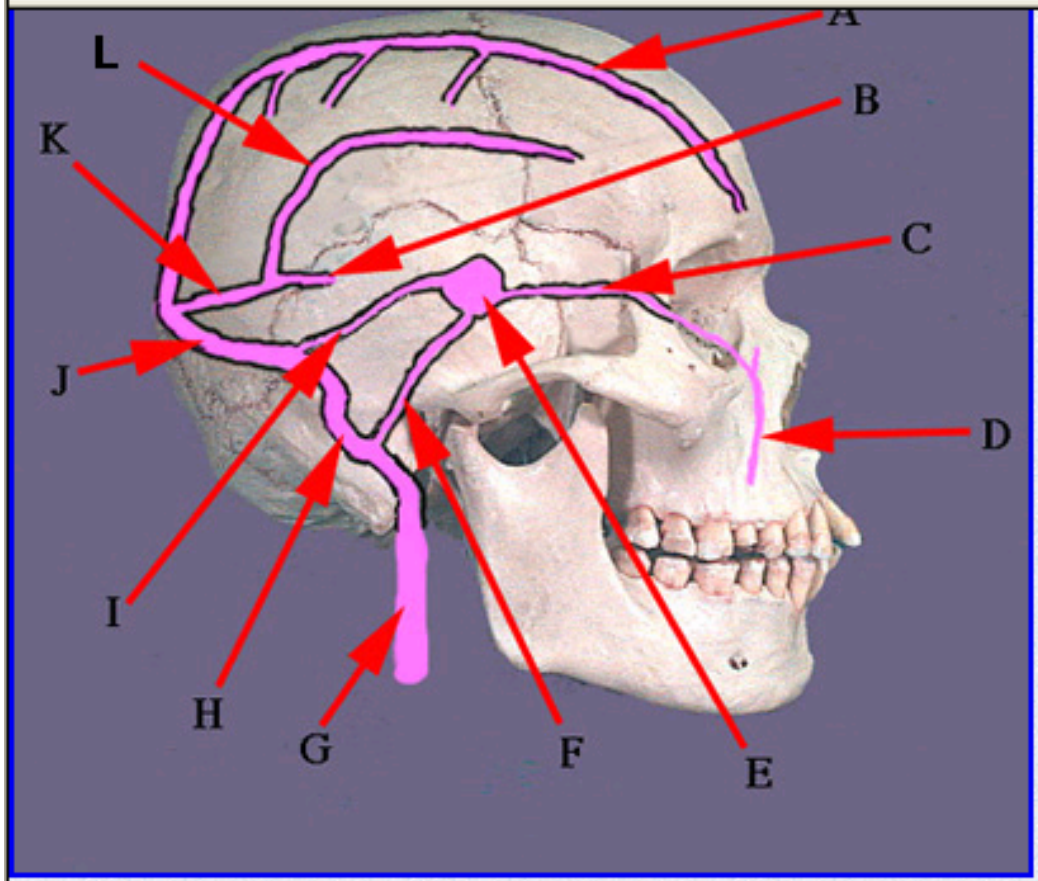
H. Superior Petrosal

I. Inferior Petrosal

J. Cavernous

K. Superior Sagittal

The Dural Venous Sinuses



Dural Venous Sinuses: Lateral View

A. Superior Sagittal Sinus

B. Great Cerebral Vein

C. Ophthalmic Veins

D. Facial Vein

E. Cavernous Sinus

F. Inferior Petrosal Sinus

G. Jugular Vein

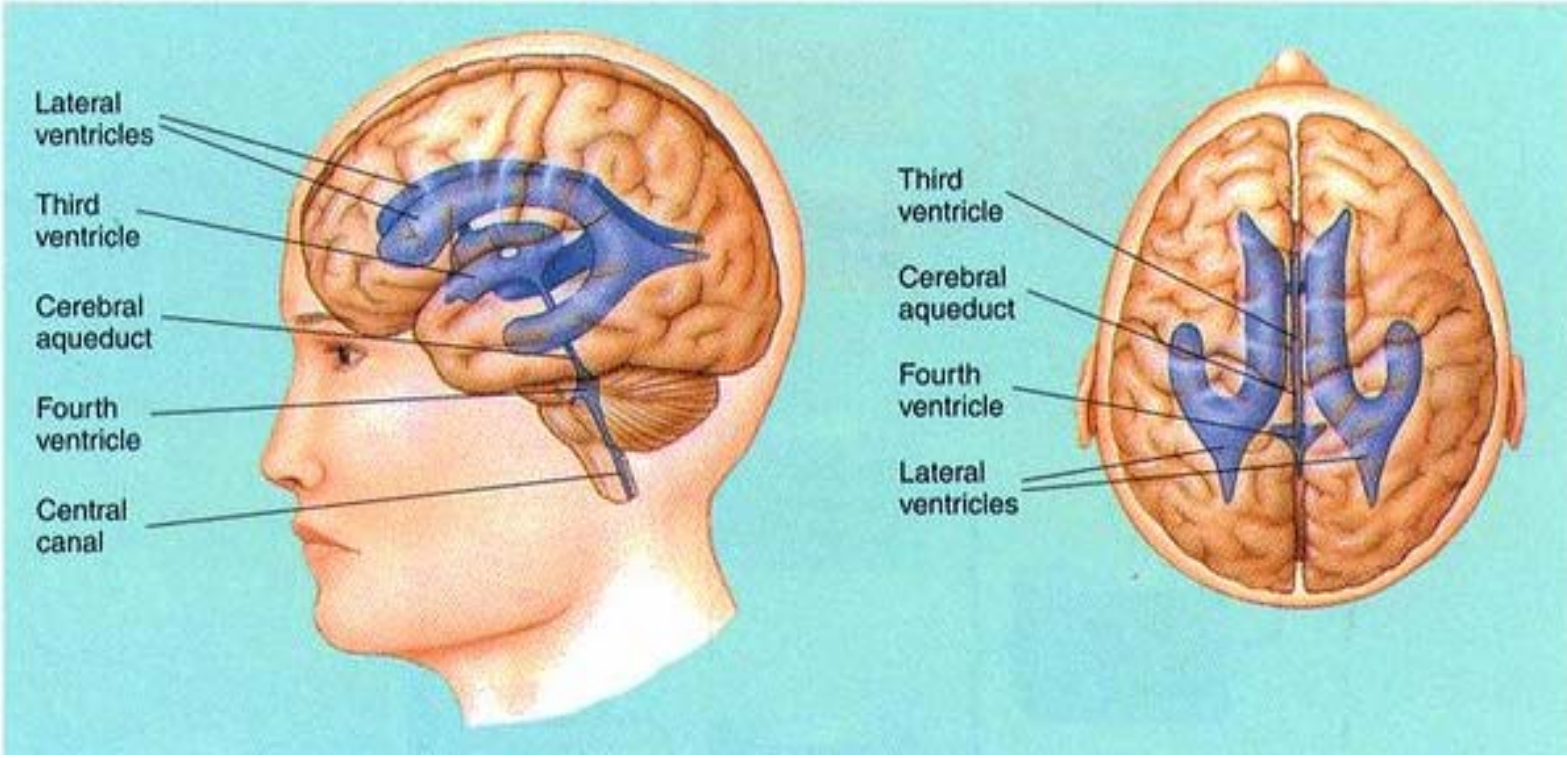
H. Sigmoid Sinus

I. Superior Petrosal Sinus

J. Transverse Sinus

K. Straight Sinus

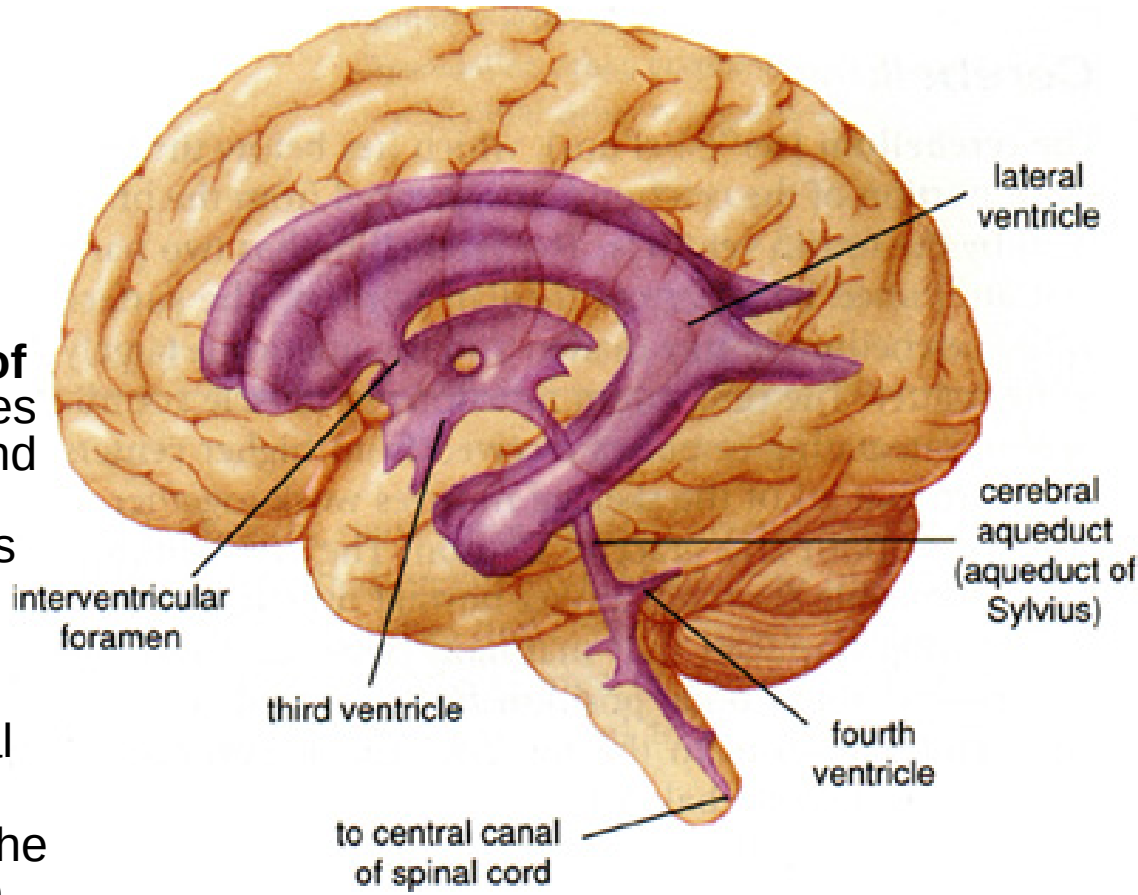
L. Inferior Sagittal Sinus



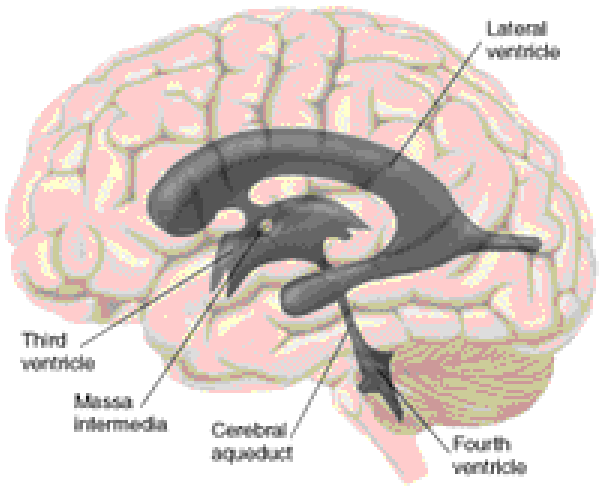
- The brain has four internal chambers called ventricles
  - **lateral ventricles-** two lateral ventricles, one in each cerebral hemisphere
  - **third ventricles-** beneath the corpus callosum and surrounded by the thalamus.
  - **fourth ventricle-** between the hemispheres of the cerebellum.

Ventricles

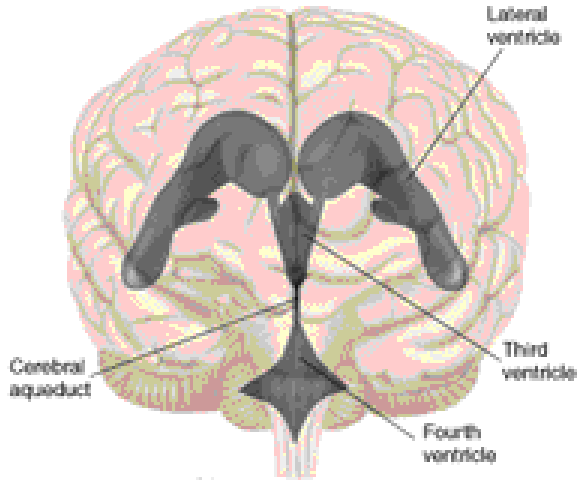
- **interventricular foramen (Foramen of Monro)-** tiny passage that connects lateral ventricles to the third ventricle
- **cerebral aqueduct (aqueduct of Sylvius**)**-** small canal that passes down the core of the midbrain and leads to the fourth ventricle (a small chamber between the pons and cerebellum
- **central canal-** extension of the fourth ventricle through the medulla oblongata into the spinal cord.
- **Foramina of Luschka-** One of the two lateral openings draining the fourth ventricle into the subarachnoid space at the cerebellopontine angle.
- **Foramen of Magendie-**, medially connects the ventricle with the subarachnoidal space.



▶ Ventricular System of the Brain



(a)



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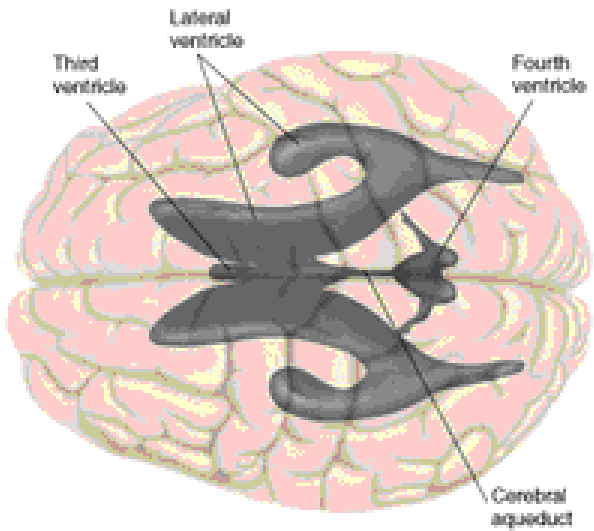

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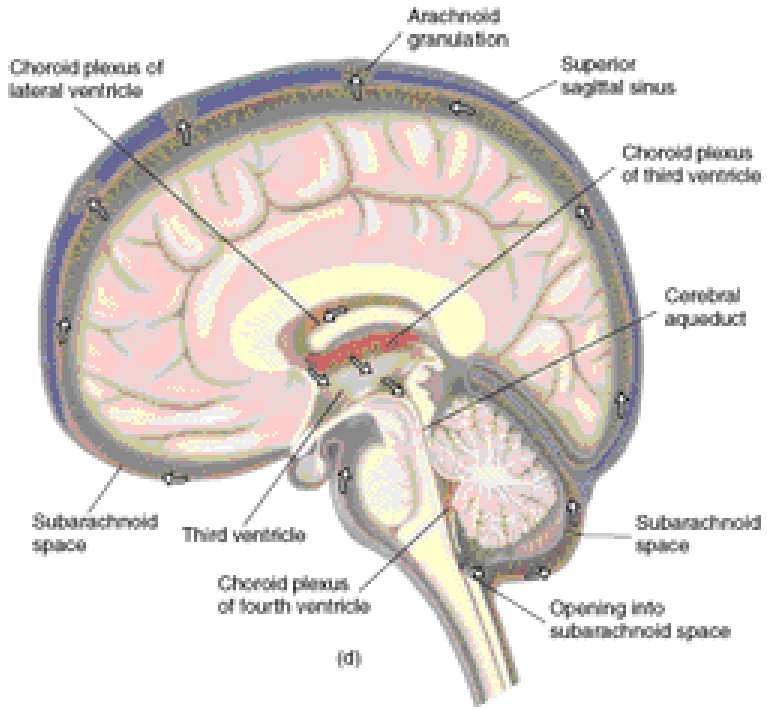
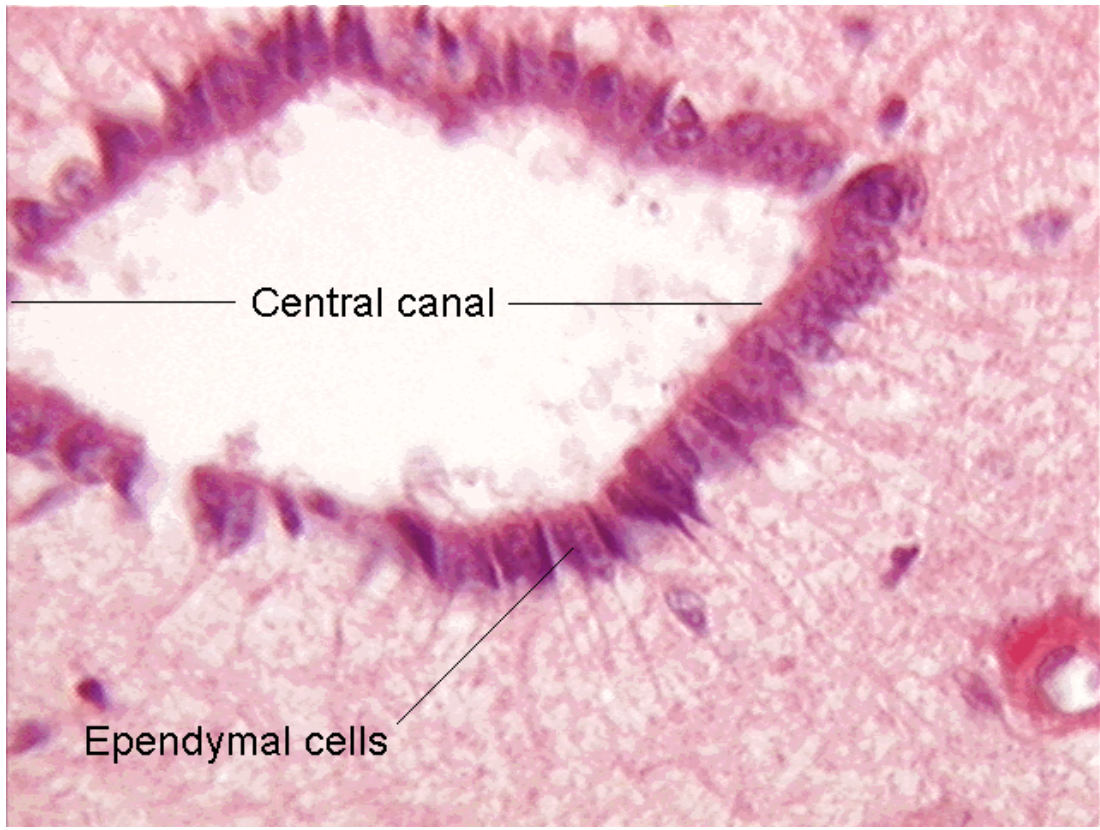


(d)

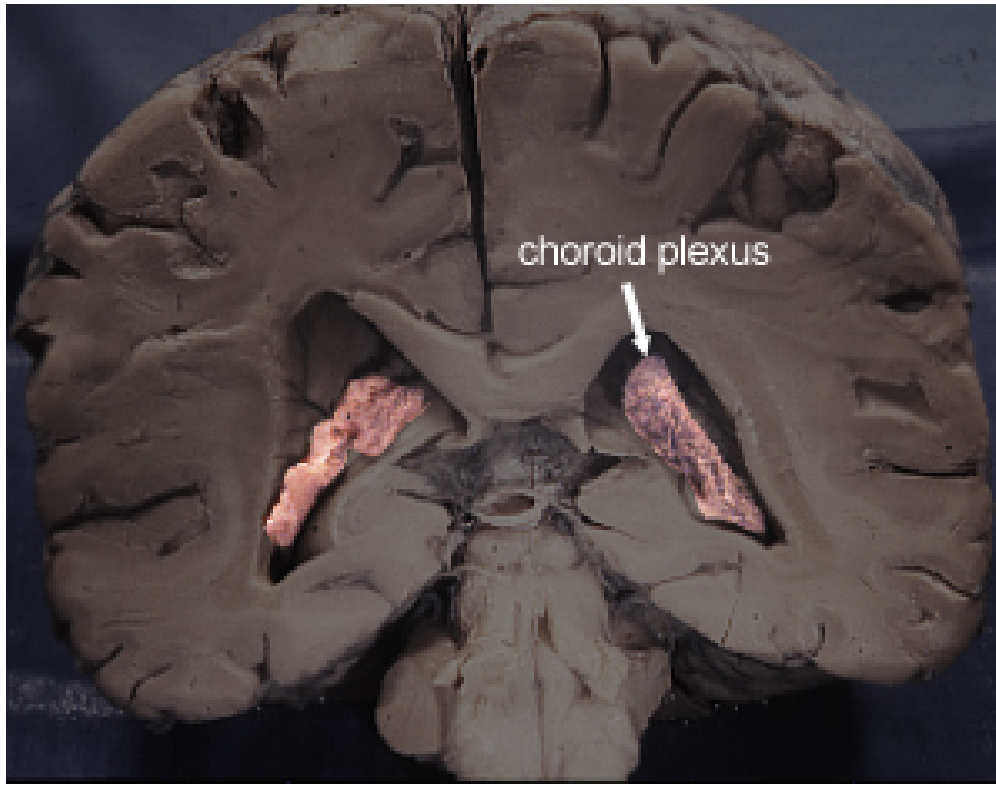
Ependymal Cells

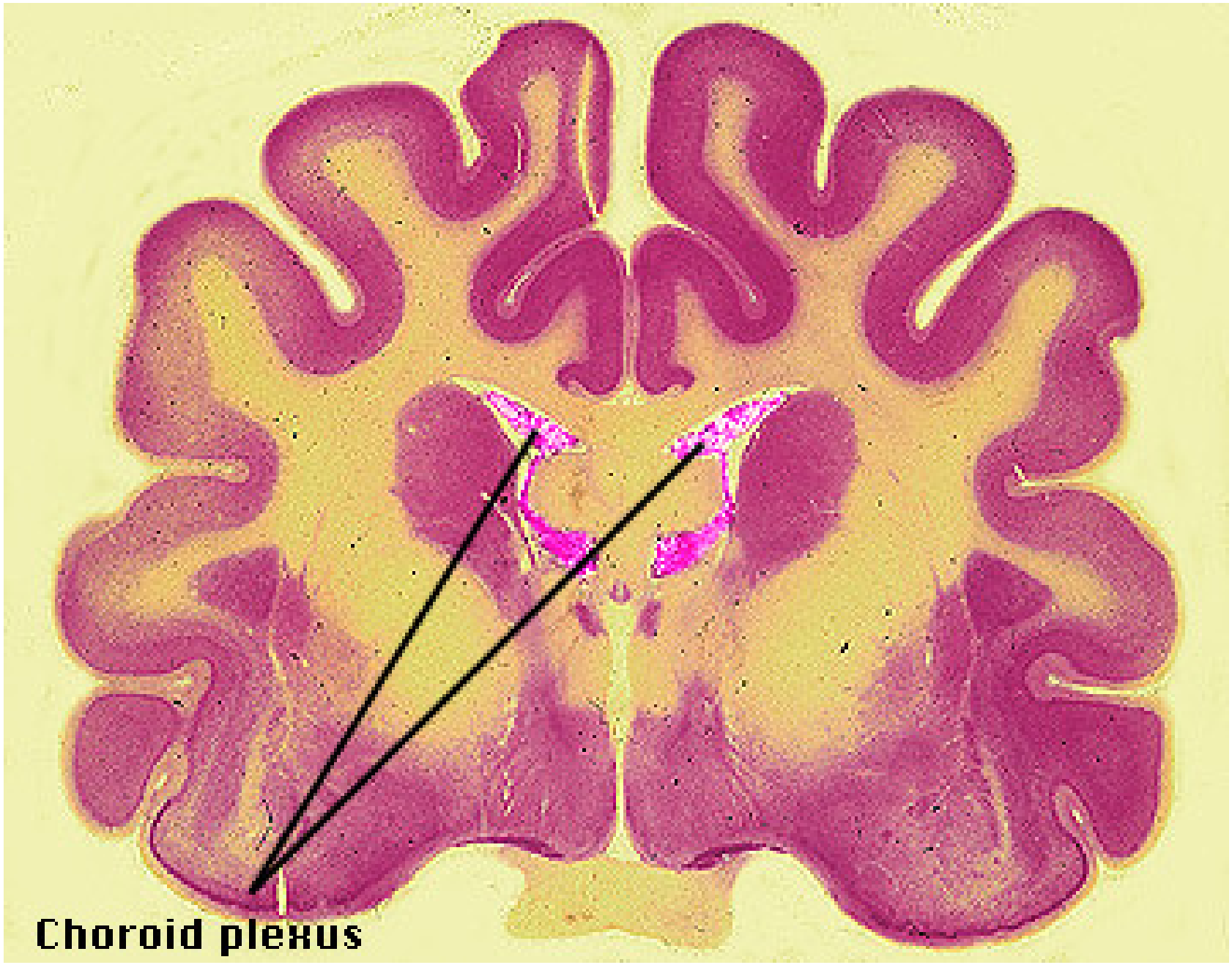
- **Ciliated cells** that line the brain's ventricles and the spinal cord's central canal and which **circulates the spinal fluid** inside the brain ventricles and the connecting central canal of the spinal cord.

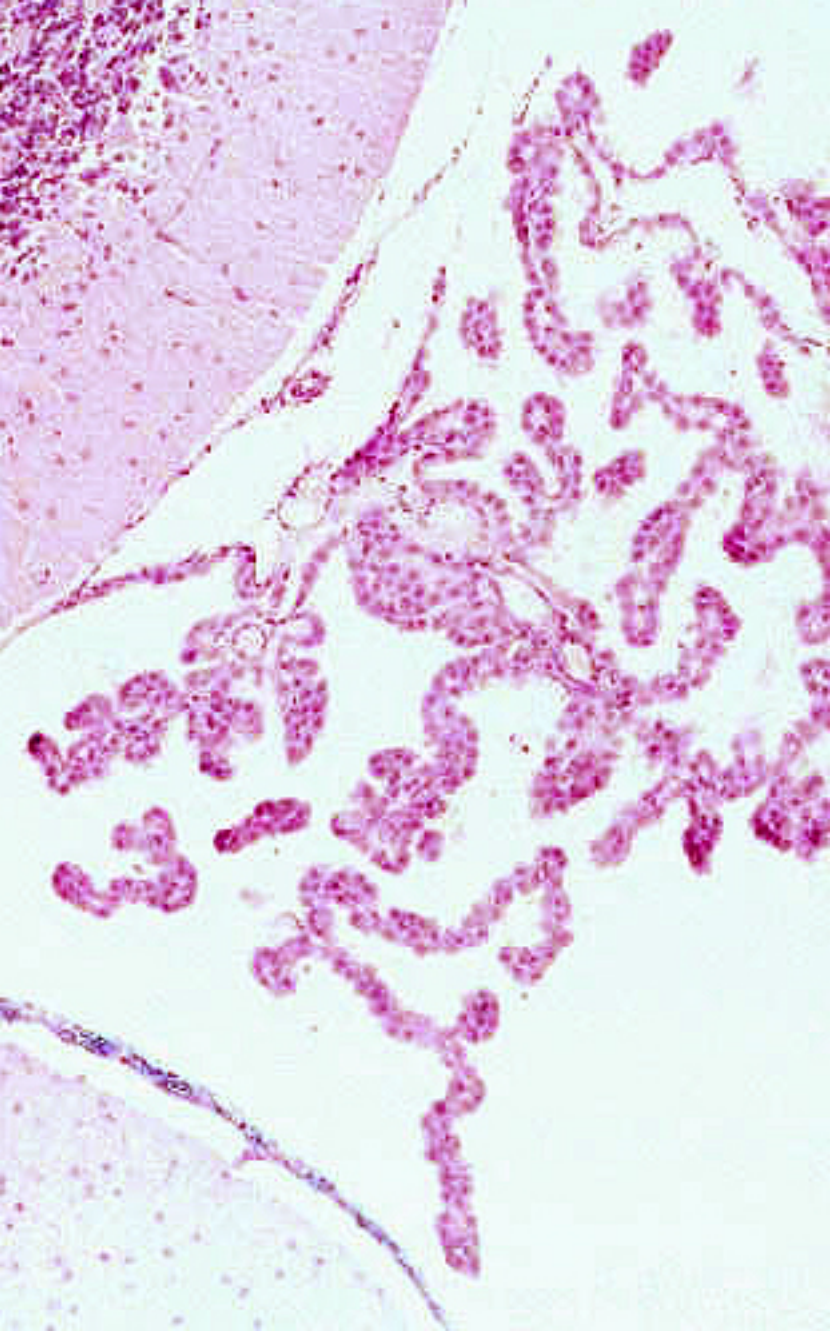


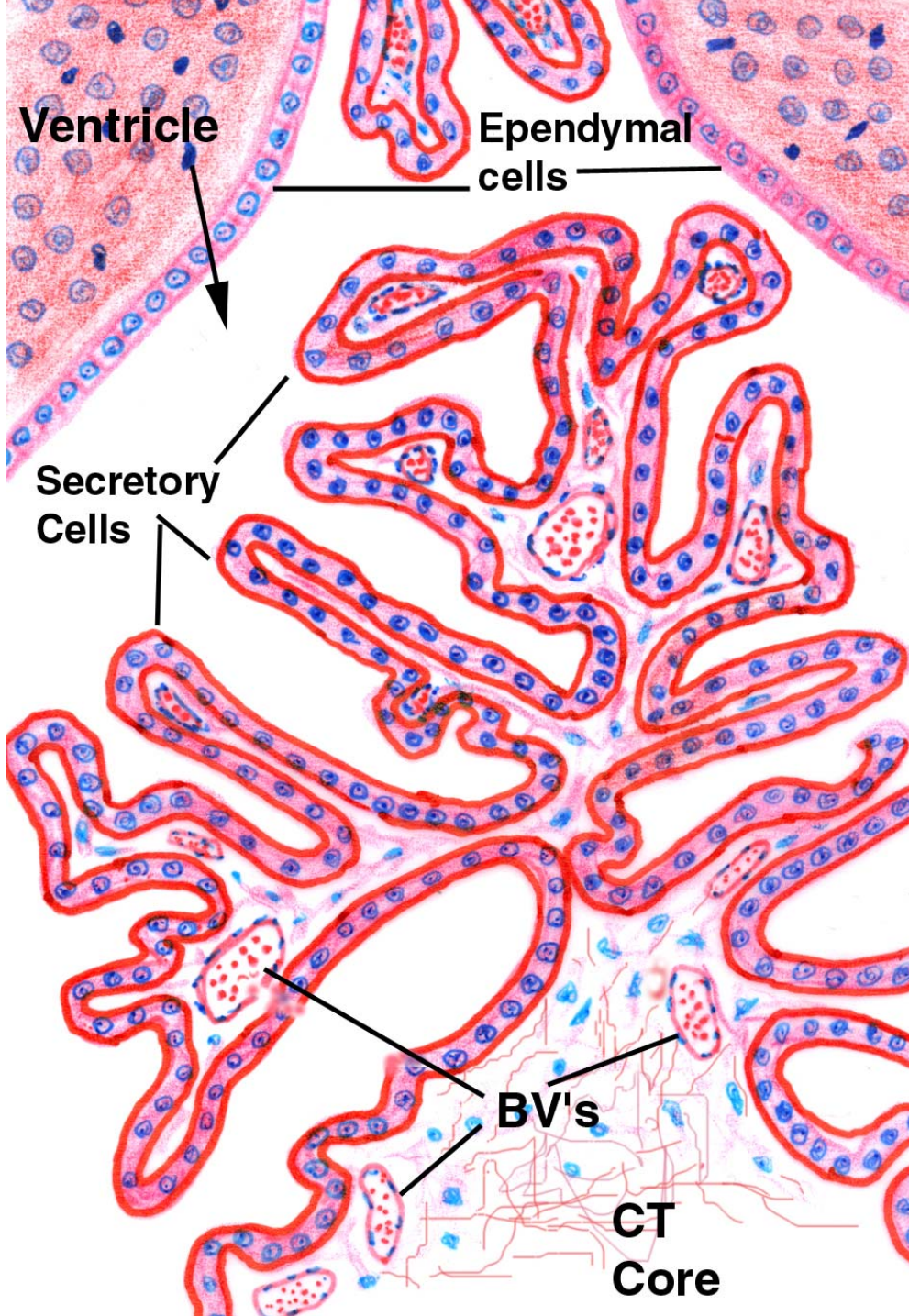
Choroid Plexus

- Found on the walls or roof of **each of the four ventricles**.
- Formed by an invagintion of the vascular pia mater (the tela choroidea)
- The epithelium that lines the choroid plexus is classified as **simple cuboidal**.
- The cells will exhibit **cilia and microvilli** at their free surface.
- This epithelial lining continues into the spinal cord and forms the **ependyma**.
- Using materials brought in the circulation, the cells of the choroid plexus **synthesize** the components of the **cerebrospinal fluid** and secrete it into the lumen of the ventricles.




Choroid plexus




Ventricle
Ependymal cells
Secretory Cells
BV's
CT Core

•Arachnoid Villi- cauliflower like extensions of the arachnoid that protrudes through the dura mater into the superior sagittal sinus

•CSF penitrates through the walls of the arachnoid villi and mixes with the blood in the sinus

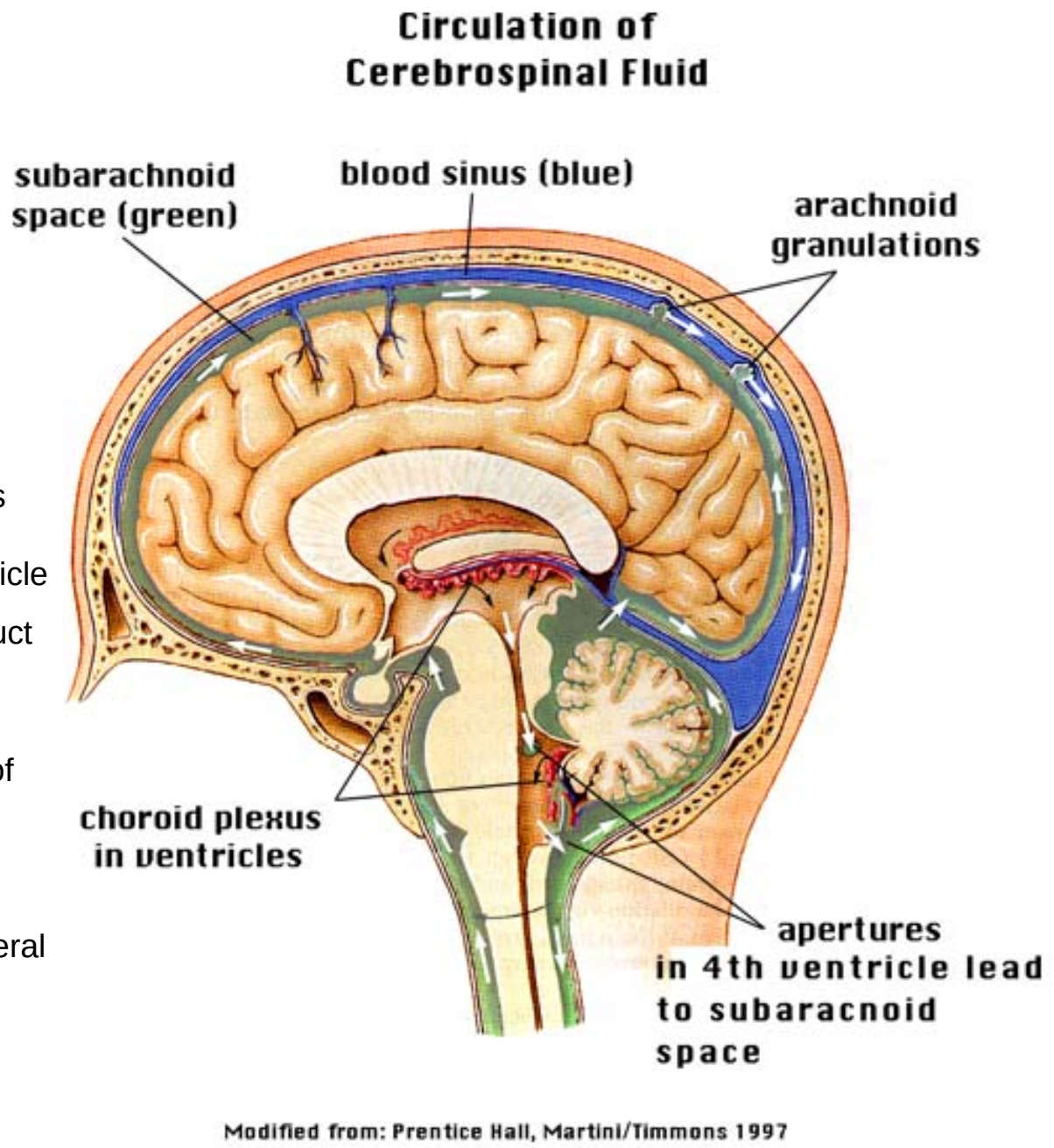
•CSF produced in the lateral ventricles pass througth the interventricular foramina (of Monro) to the third ventricle

•and then through the cerebral aqueduct (of Sylvius) into the fourth ventricle.

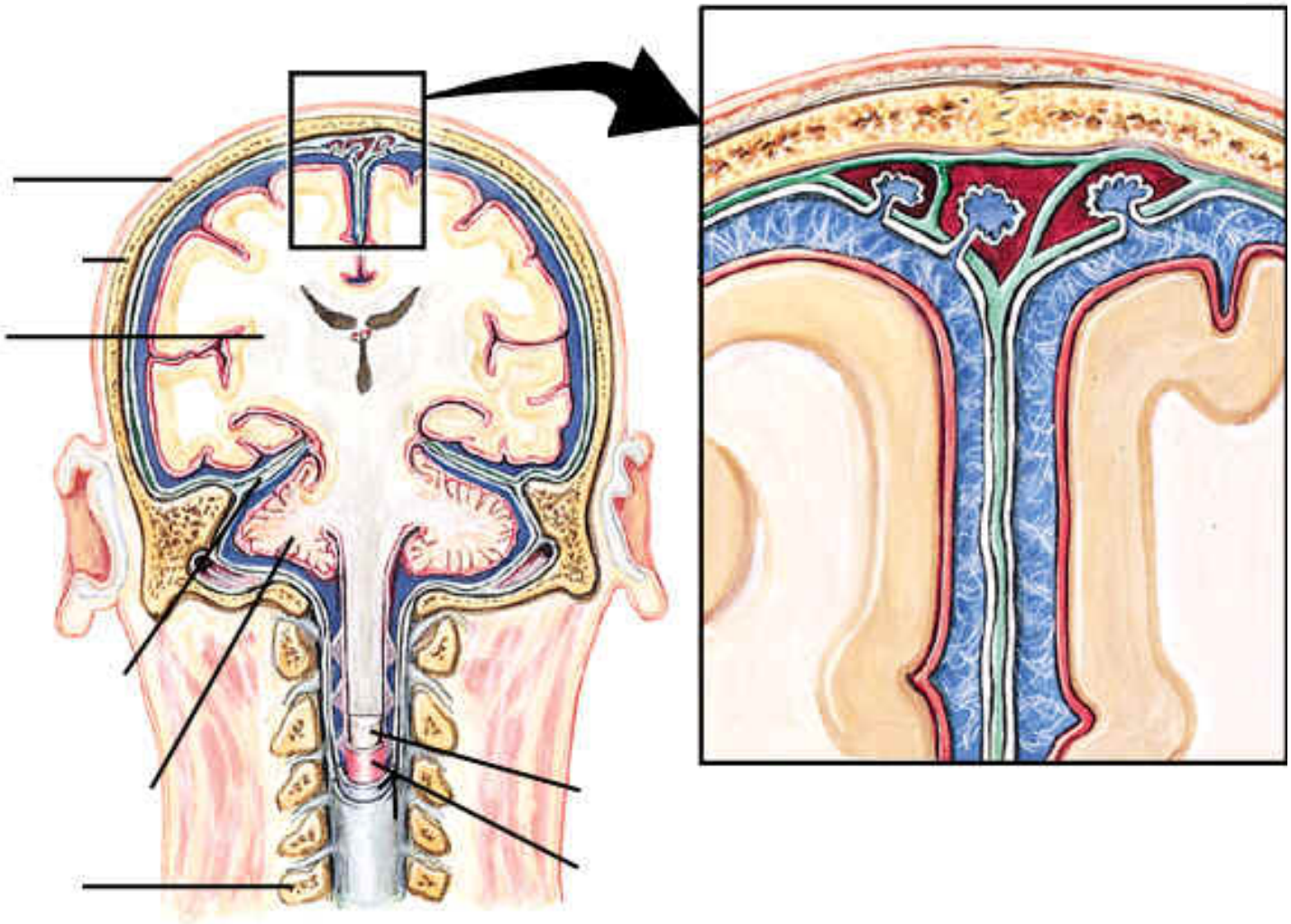
•The CSF reaches the subarachnoid space through the median aperture (of Magendie) and through the lateral apertures (of Luschka) of the fourth ventricle.

•flows upward over the medial and lateral surfaces of the cerebral hemispheres toward the superior sagittal sinus,

•is taken up by the arachnoid granulations

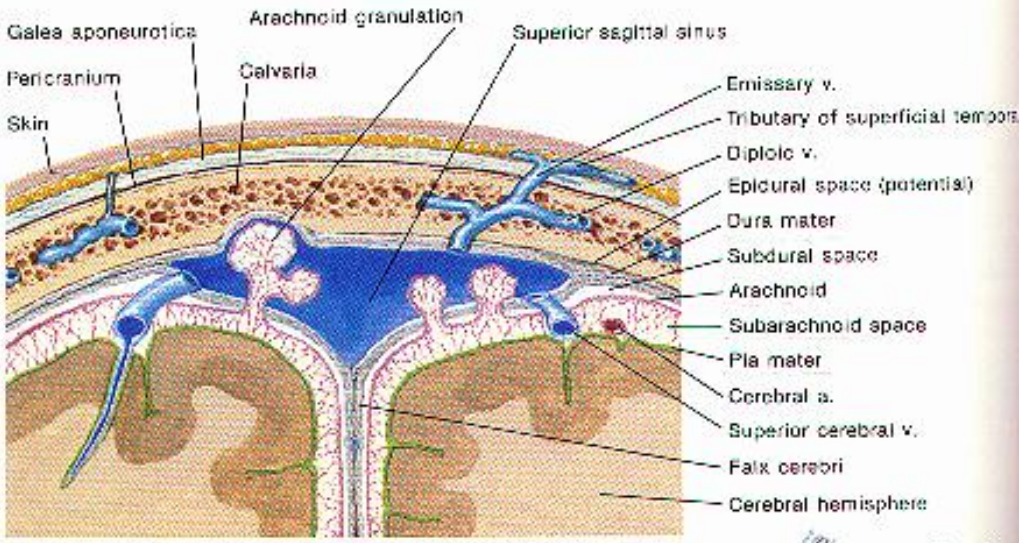


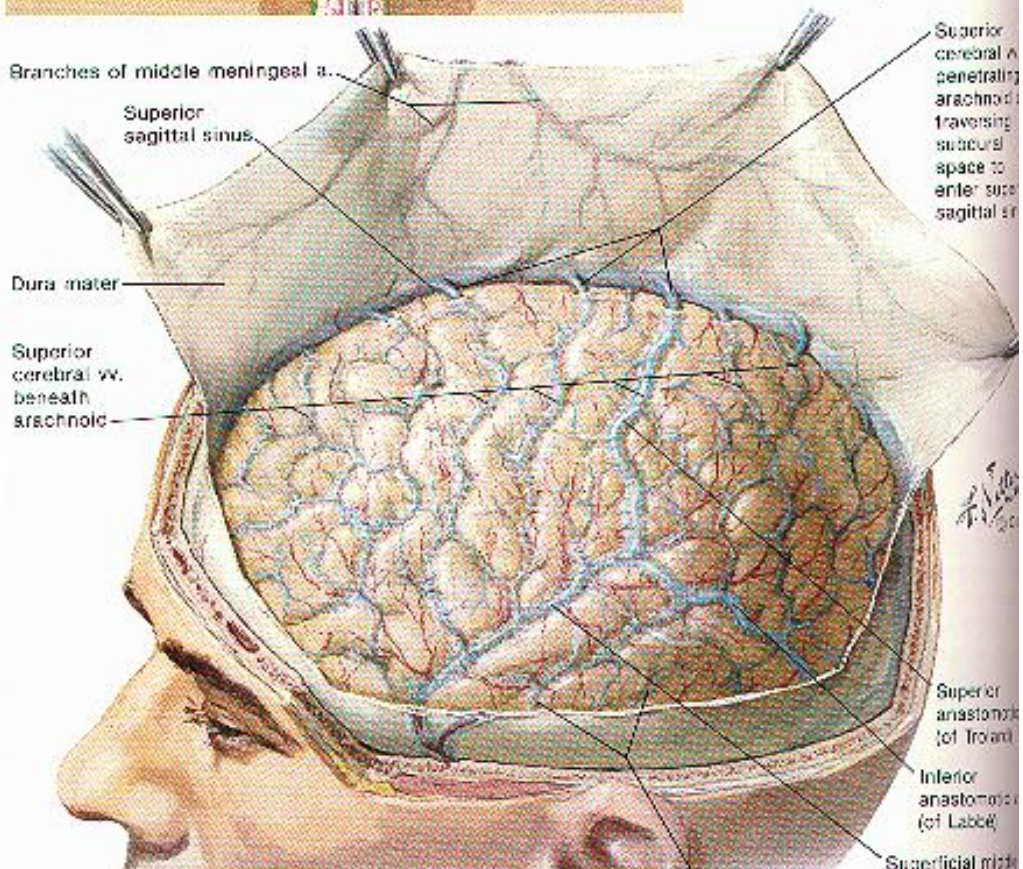
Arachnoid Granulations (Villi)

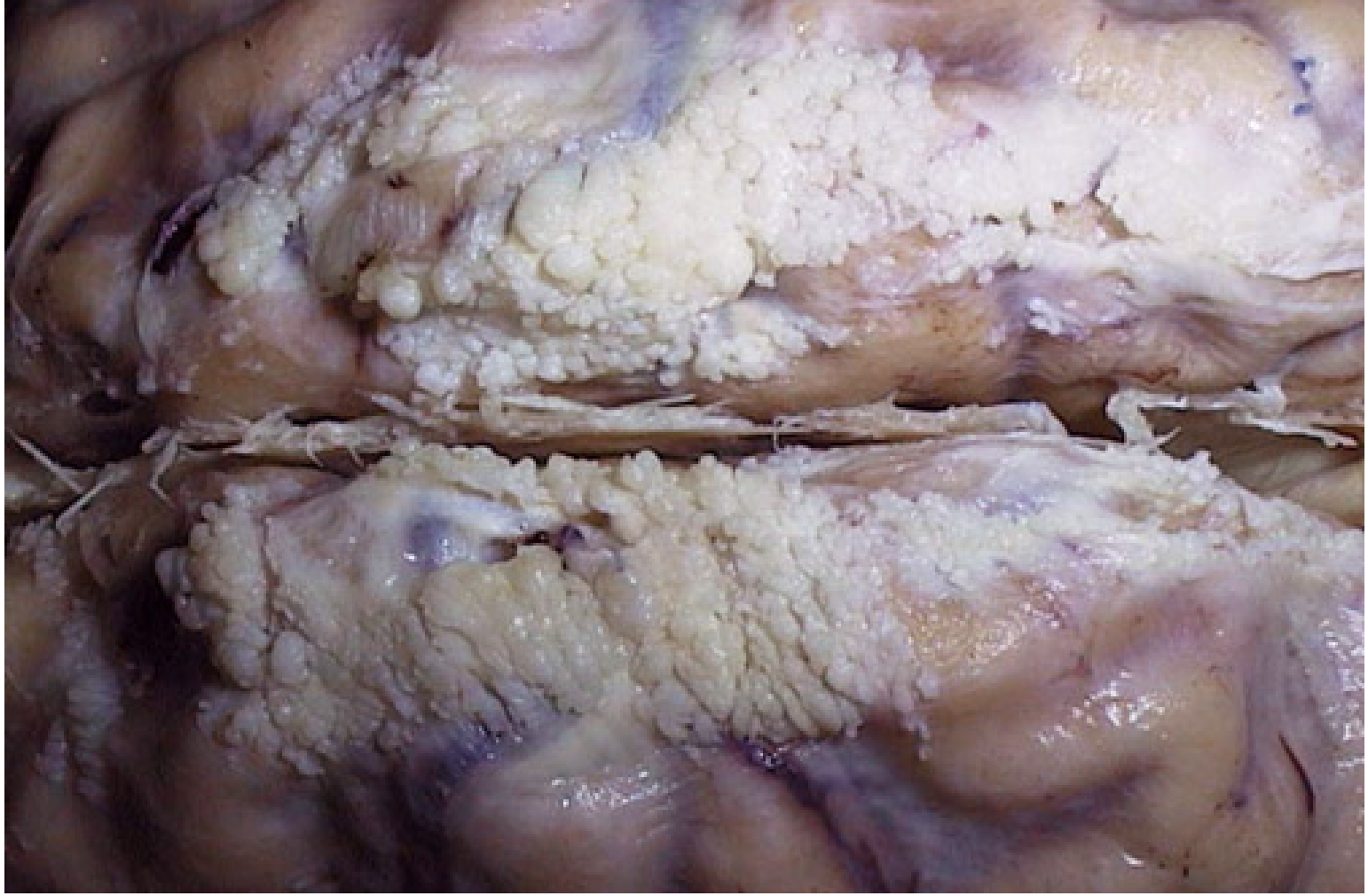


- This is **where the cerebrospinal fluid** produced in the choroid plexuses of the ventricles and which has circulated out of the foramina of Magendie and Luschka and into the subarachnoid space **is reabsorbed**.

Meninges and Superficial Cerebral Veins







- The nodular white excresences seen here over the cerebral hemispheres at the vertex on both sides of the central fissure with falx cerebri of the brain are the arachnoid granulations.

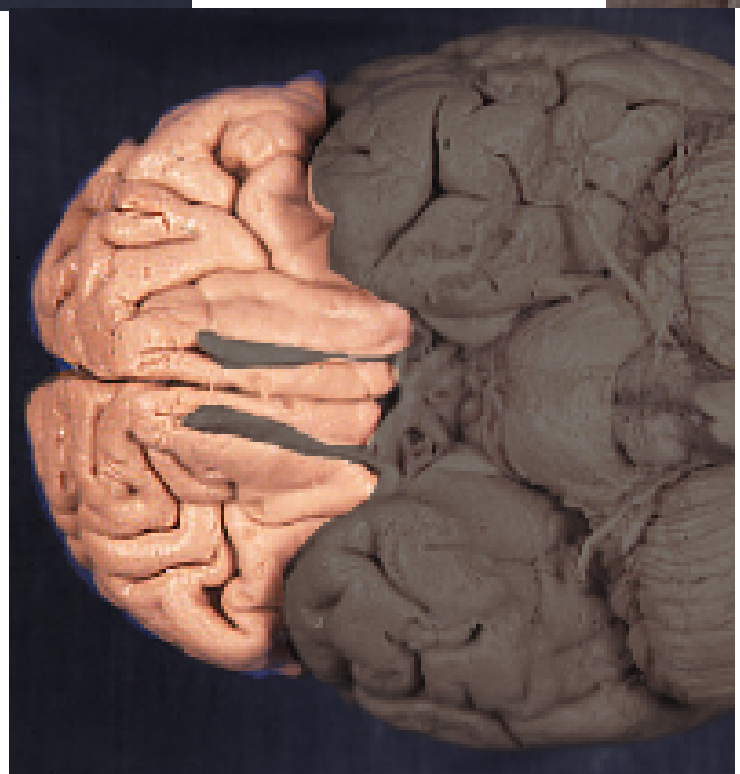
Cerebrospinal fluid

- produced by the choroid plexuses of the lateral, third and fourth ventricles.
- Aids in maintaining the chemical environment of the central nervous system and the removal harmful chemical waste.
- provides a protective buoyancy for the brain which effectively makes the weight of the brain 1/30th of its actual weight,
- Similar in chemical composition to plasma but with a lot less proteins
- The entire CSF is replaced four times a day so that the total amount of CSF produced is approximately 600ml in 24 hours.

Comparison of plasma and CSF composition.

	Plasma	CSF
Na^+ (mM)	155	151
K^+ (mM)	4.6	3.0
Mg^{2+} (mM)	0.7	1.0
Ca^{2+} (mM)	2.9	1.4
Cl^- (mM)	121	133
HCO_3^- (mM)	26.2	25.8
Glucose (mM)	6.3	4.2
Amino acids (mM)	2.3	0.8
Protein (mg/100g-1)	6500	25

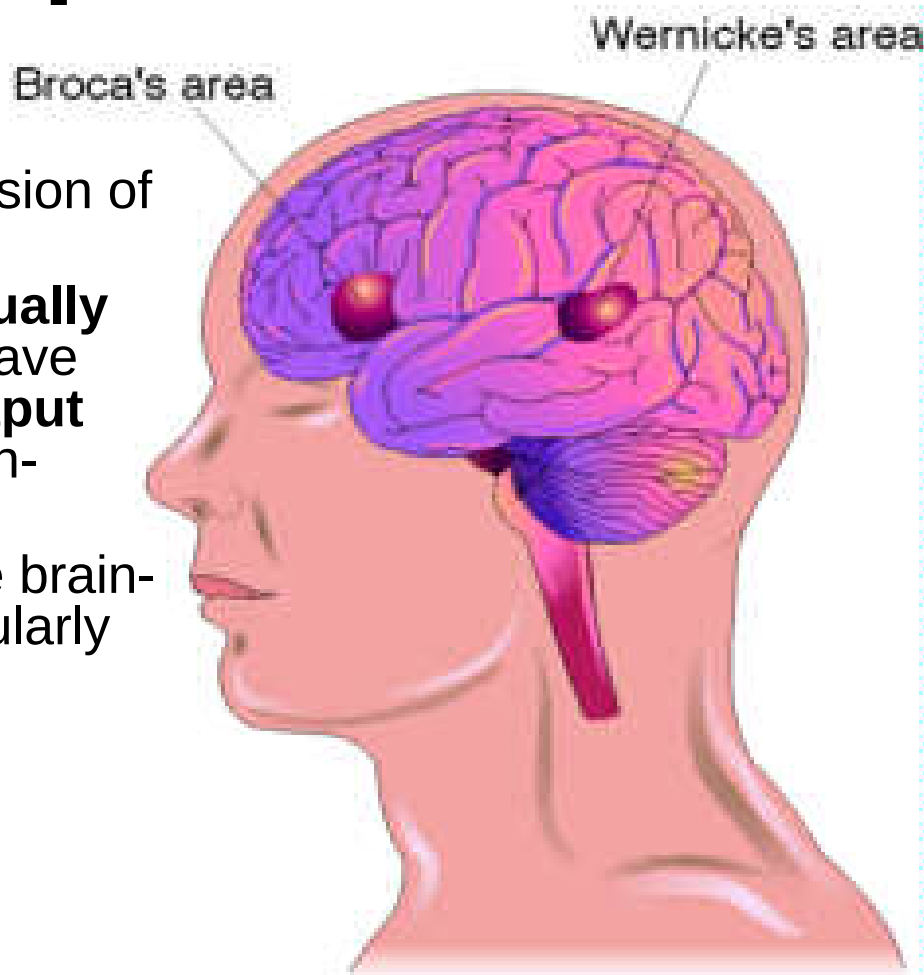
Frontal Lobe



Frontal Lobe

- Frontal Lobe-
  - voluntary and planned motor behaviors - such things as voluntary movement of eyes, trunk, limbs and the many muscles used for speech
    - The motor speech area **(Broca's area)** is usually **in the frontal lobe of the left hemisphere** regardless of which hemisphere is dominant for handedness (i.e. the left hemisphere for right handers).
      - It is one of the main language areas in the cerebral cortex because it **controls the motor aspects of speech**.
  - senory reception, and integration of somesthetic, taste, and some visual information

Broca's aphasia

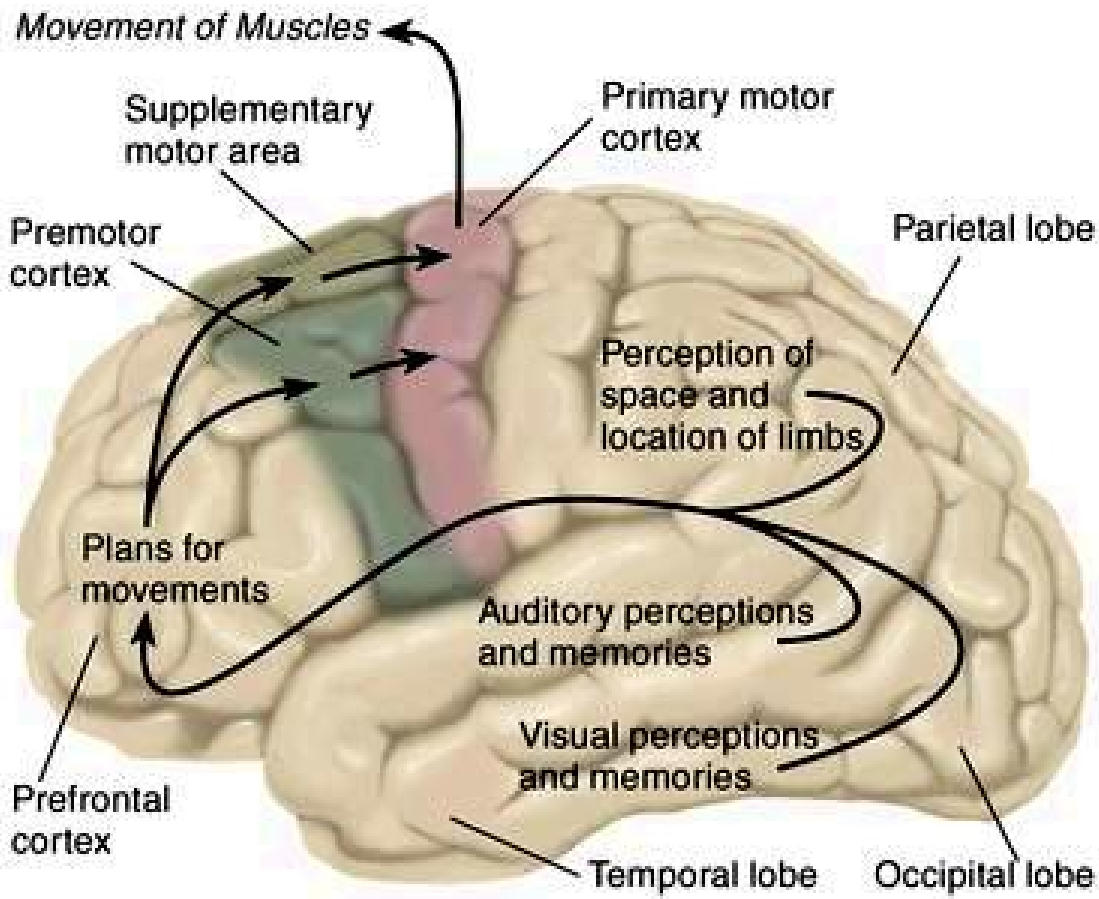


- Aphasia is an impairment of language, affecting the production or comprehension of speech and the ability to read or write.
- Persons with a Broca aphasia **can usually understand what words** mean, but have **trouble performing the motor or output** aspects of speech. ("Expressive," "Non-fluent," or "Motor" Aphasia)
- Aphasia is always **due to injury** to the brain- most commonly **from a stroke**, particularly in older individuals.

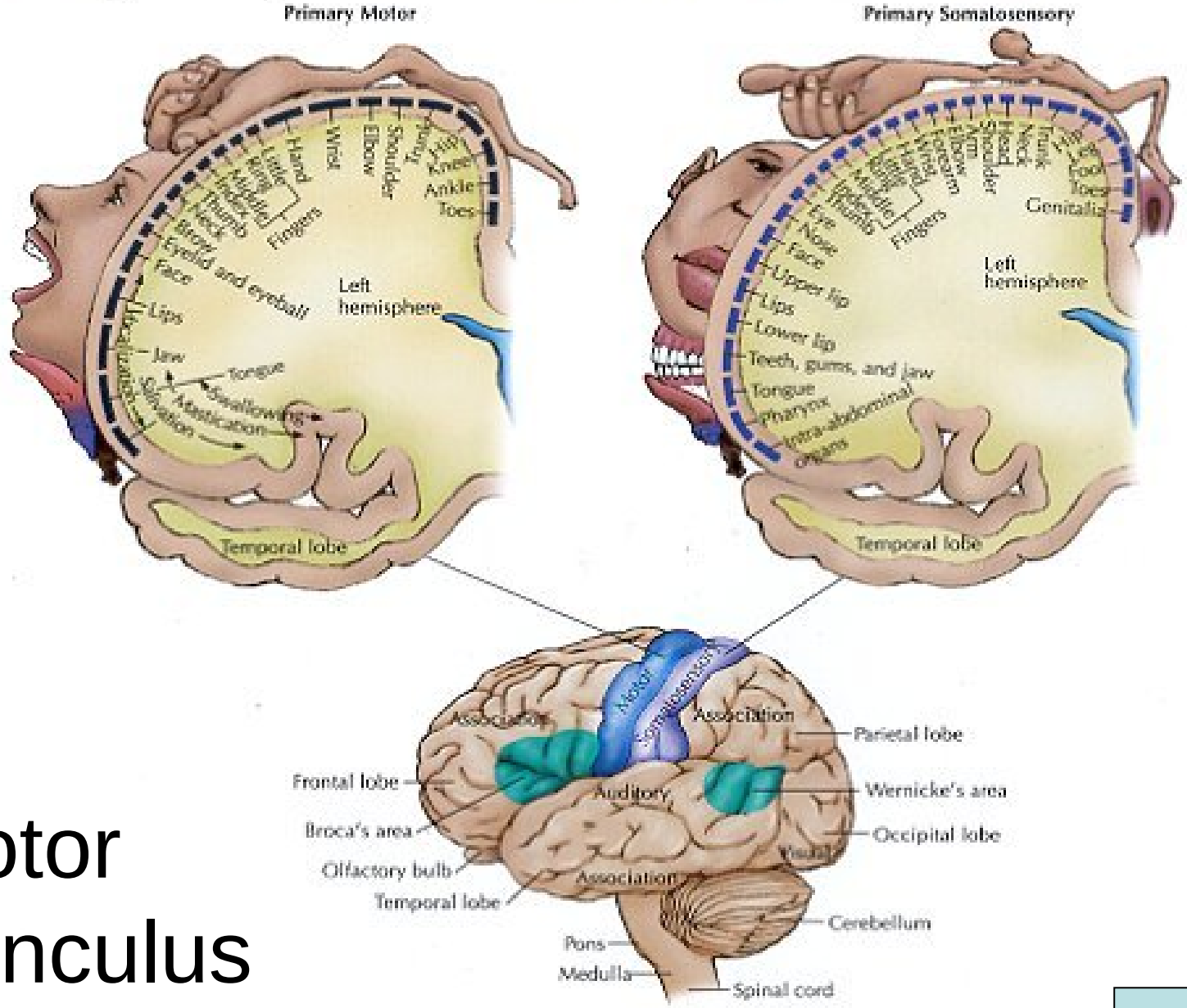
normal

Yes ... ah ... Monday ... er Dad and Peter H ... (his own name), and Dad ... er hospital ... and ah ... Wednesday ... Wednesday nine o'clock ... and oh ... Thursday ... ten o'clock, ah doctors ... two ... an' doctors ... and er ... teeth ... yah.

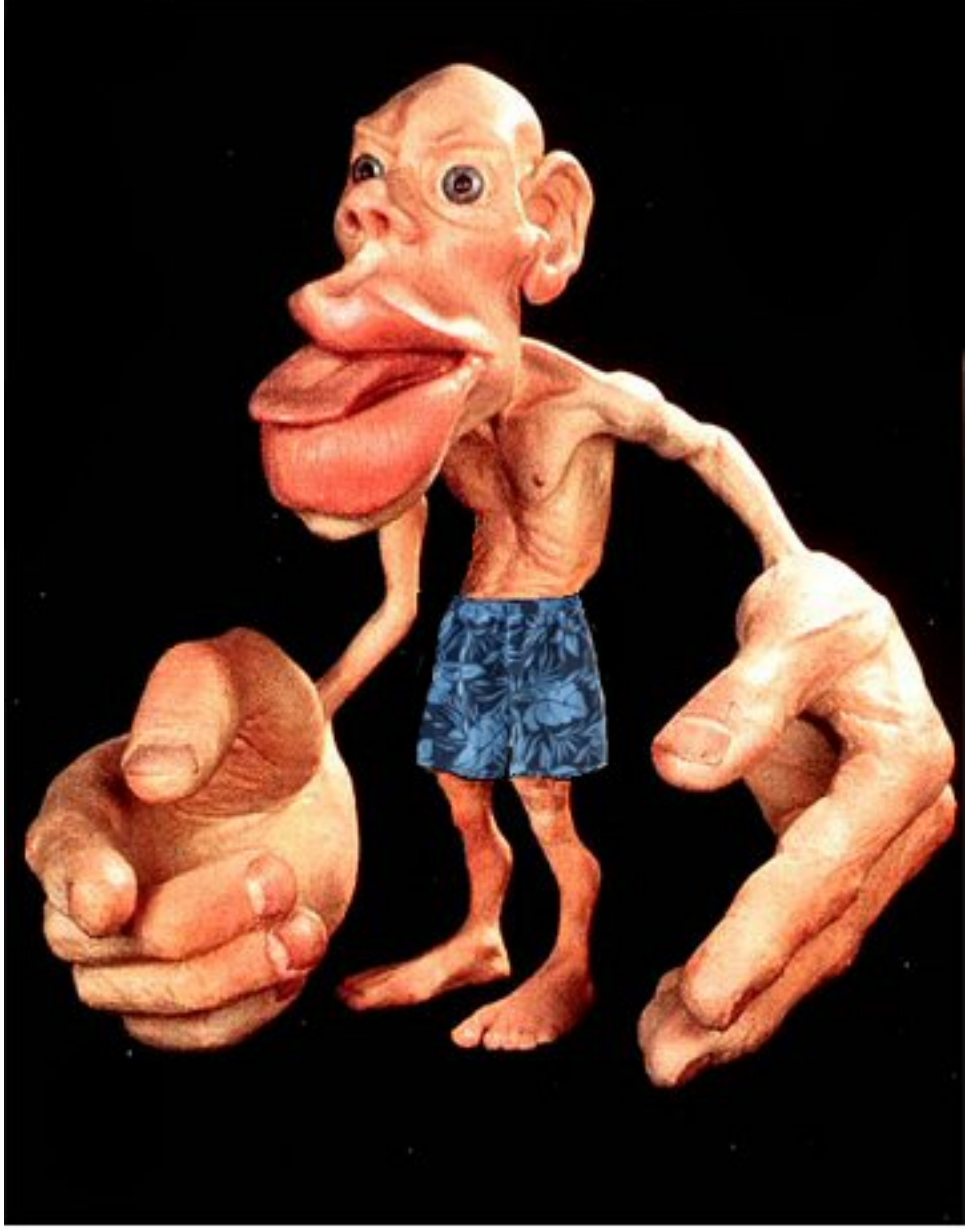
▶ Cortical Control of Movement



Primary sensory, motor, and association areas of the cerebral cortex



Motor Homunculus

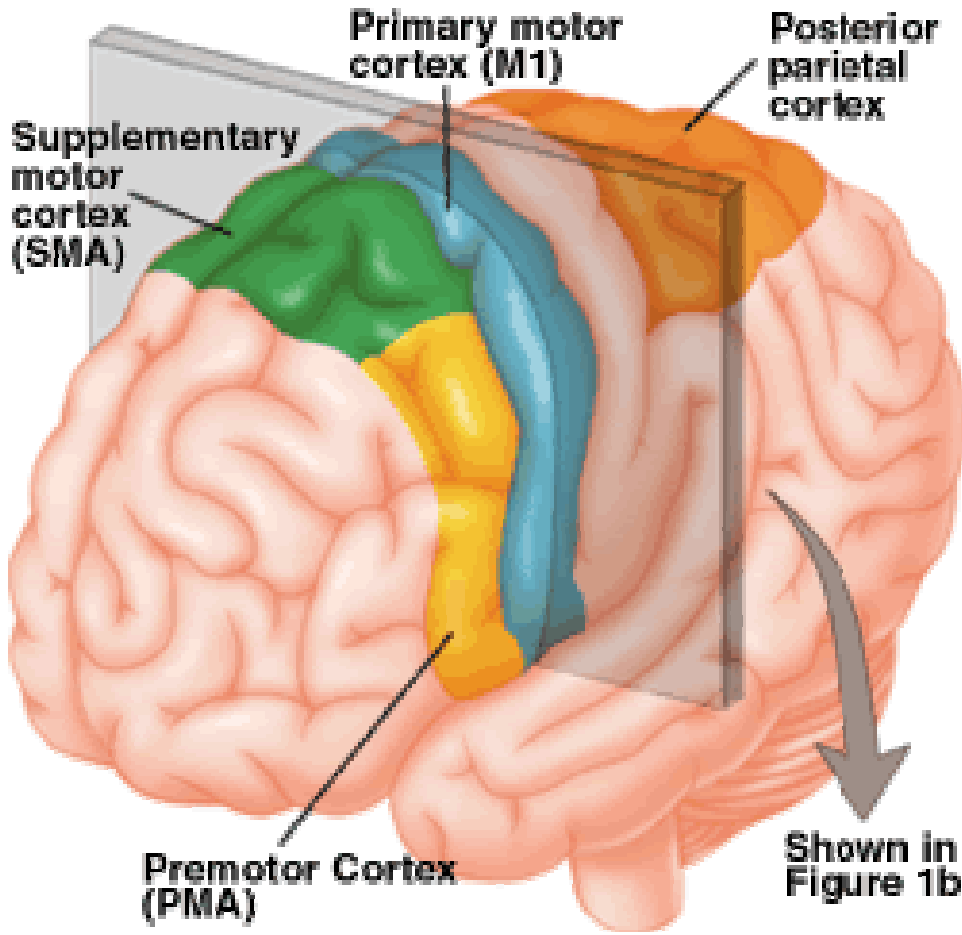


This somatosensory homunculus, or "little man," is drawn to show the dispropotionate amount of brain area devoted to sensory input.

L. L. Bean shorts added by aaw on 25-Feb0-04.

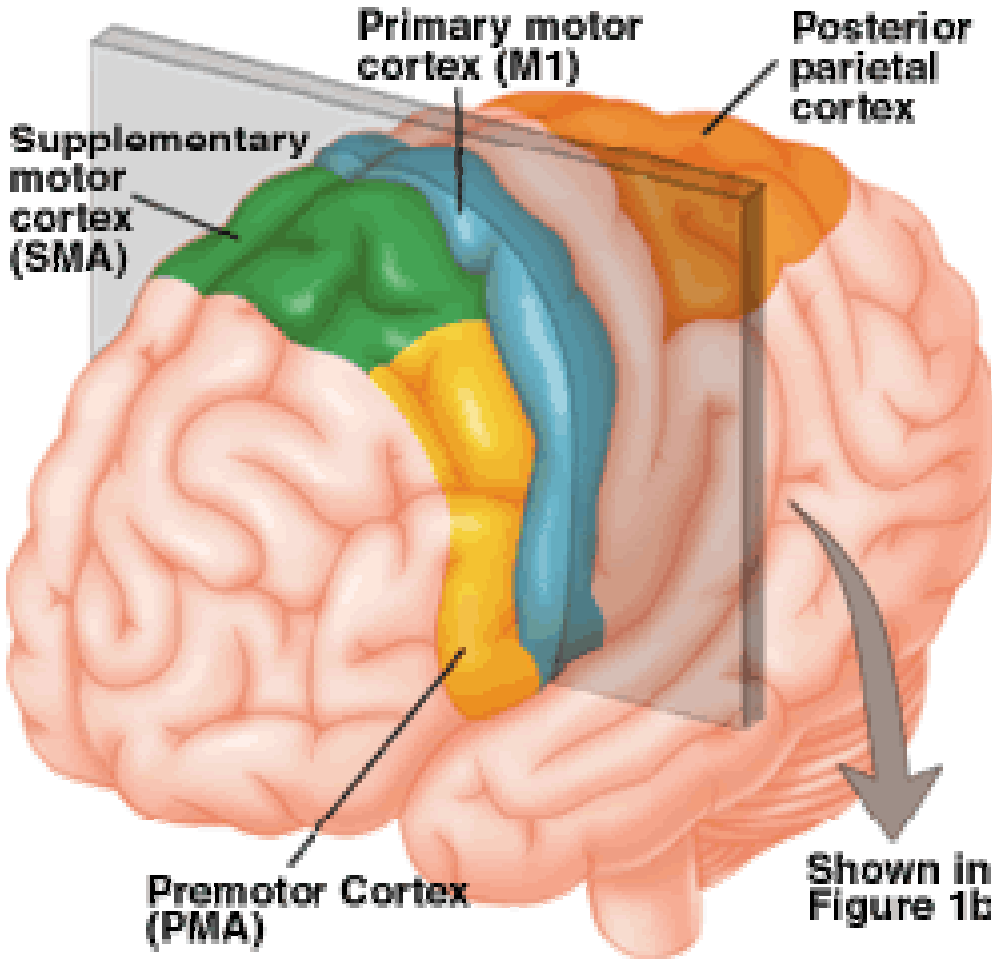
primary motor cortex

- is one of the principal areas involved in motor function.
- The role is to generate neural impulses that control the execution of movement.
- the left hemisphere of the brain controls the right side of the body, and the right hemisphere controls the left side of the body.

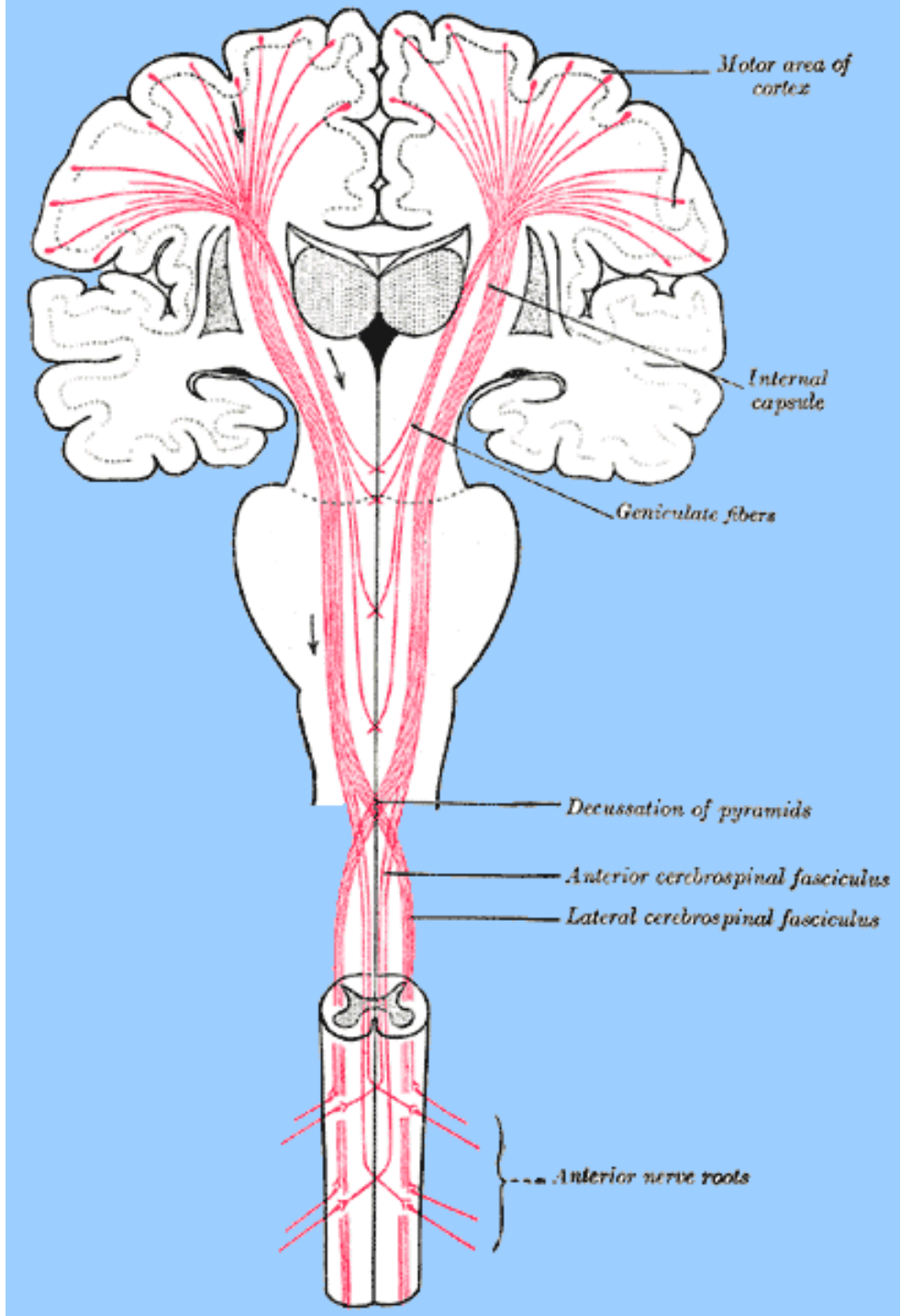


Other Cortical Regions Involved in Motor Function (Secondary Motor Cortices)

- **posterior parietal cortex-** involved in transforming visual information into motor commands.
  - Ex: determining how to steer the arm to a glass of water based on where the glass is located in space.
- **premotor cortex-**involved in the sensory guidance of movement, and controls the more proximal muscles and trunk muscles of the body.
  - Ex: the premotor cortex would help to orient the body before reaching for the glass of water.
- **supplementary motor area** (SMA)- It is involved in the planning of complex movements and in coordinating two-handed movements.



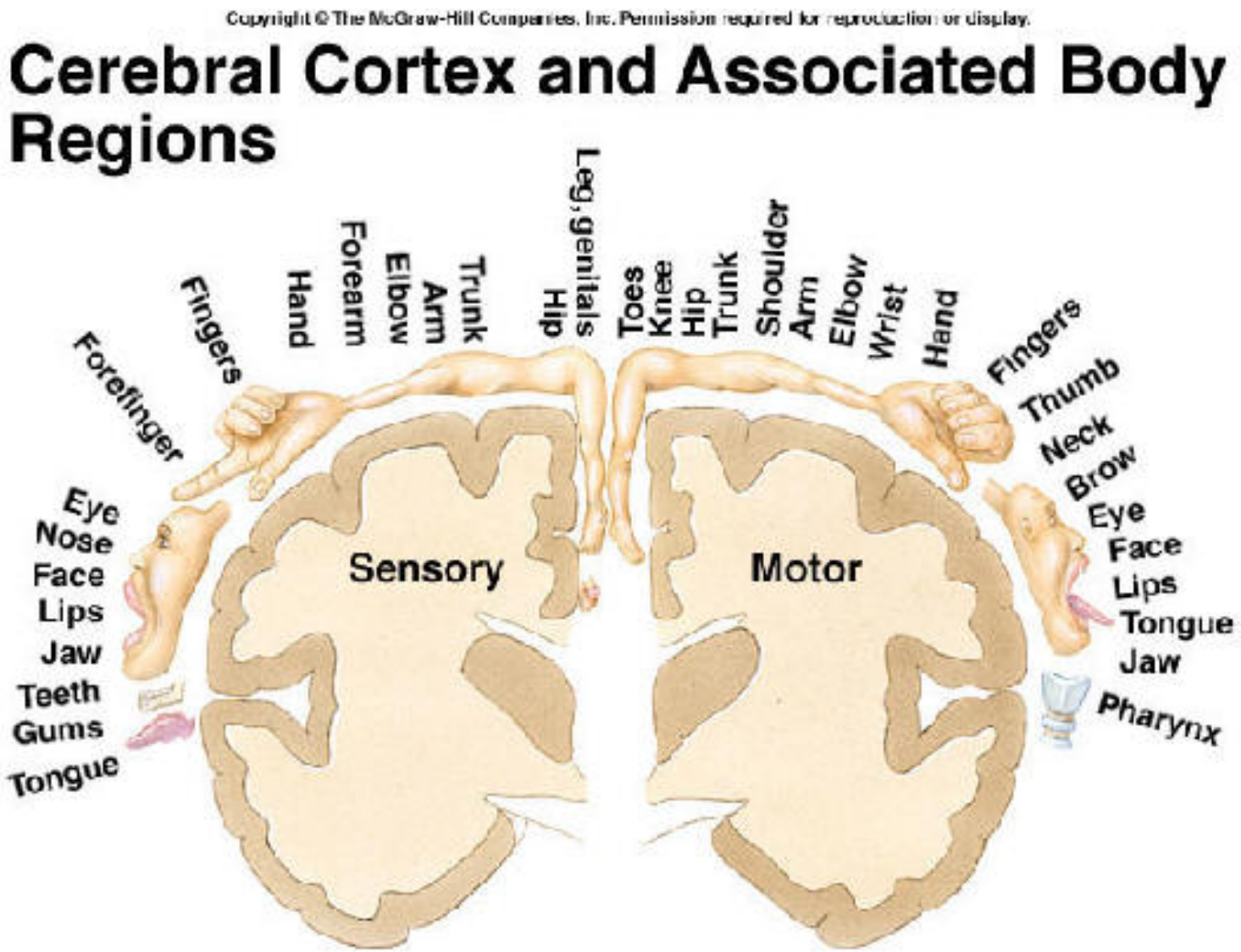
- Neurons in M1, SMA and premotor cortex give rise to the fibers of the **corticospinal tract.**
- the **only direct pathway from the cortex to the spine**
- is the **main pathway for control of voluntary movement in humans.**
- fibers descend through the brainstem where the majority of them cross over (disscusates) to the opposite side of the body.
- there are other motor pathways which originate from **subcortical** groups of **motor neurons** (nuclei).
- These pathways **control posture** and **balance**, **coarse movements** of the proximal muscles, and **coordinate head, neck and eye movements in response to visual targets.**
- **Subcortical pathways can modify voluntary movement** through interneuronal circuits in the spine and through projections to cortical motor regions.



Parietal Lobe

Concerned with sensory reception and integration of somesthetic (touch, pressure, stretch, movement, heat, cold, and pain), taste, and some visual informatioan

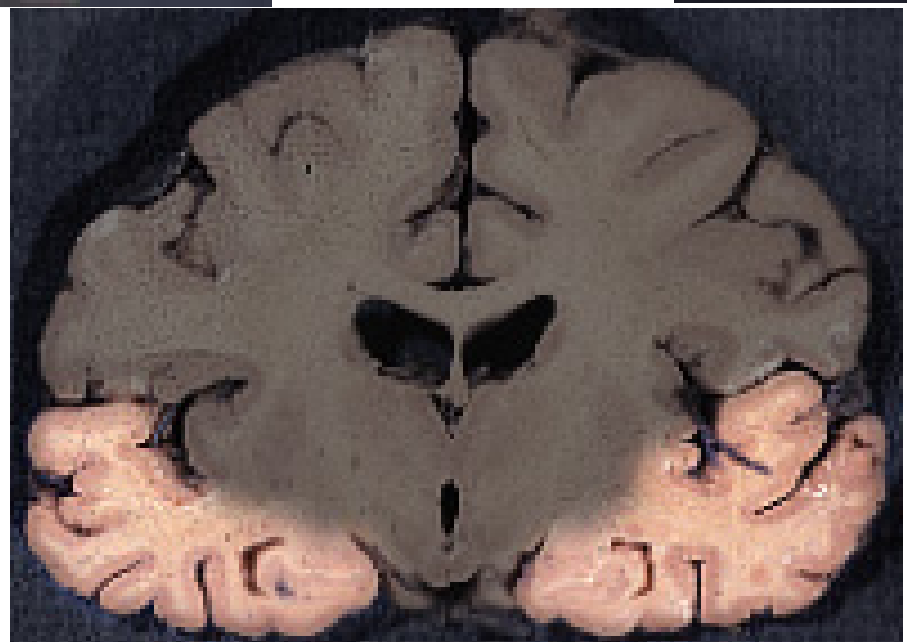
Sensory Homunculus



Parietal Lobe

- Right Parietal Lobe - Damage to this area can cause visuo-spatial deficits (e.g., the patient may have difficulty finding their way around new, or even familiar, places).
- Left Parietal Lobe - Damage to this area may disrupt a patient's ability to understand spoken and/or written language)

Various parts of it are important for the sense of hearing, for certain aspects of memory, and for emotional/affective behavior.



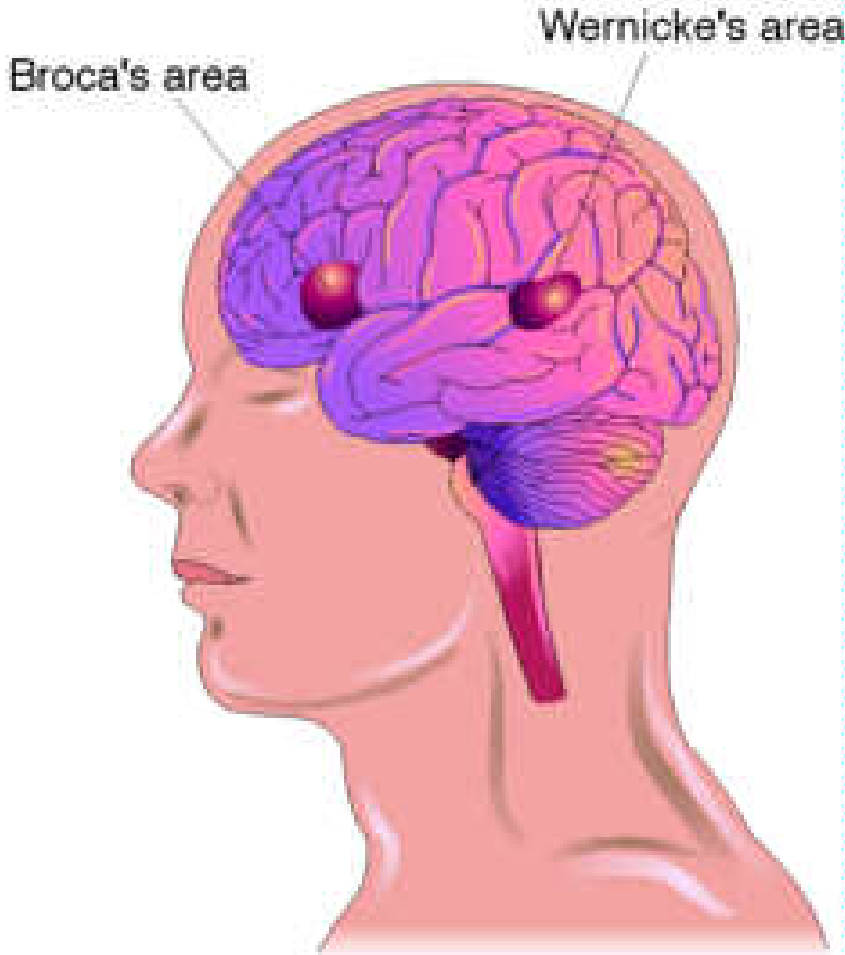
Temporal Lobe

Temporal Lobe

- Various parts of it are important for the sense of hearing, for certain aspects of memory, and for emotional/affective behavior.
- Right Lobe - Mainly involved in visual memory (i.e., memory for pictures and faces).
- Left Lobe - Mainly involved in verbal memory (i.e., memory for words and names).

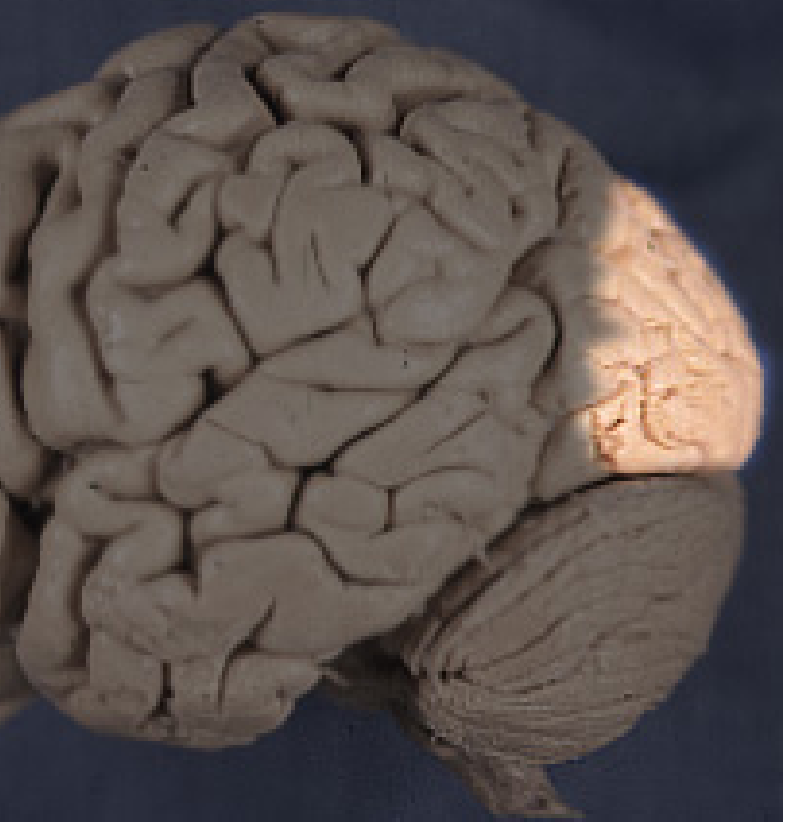
Wernicke's aphasia

- associated with the ability to <u>understand</u> and <u>produce</u> meaningful speech
- Individuals with Wernicke's aphasia speak extremely fluently but with no informative purpose ("fluent aphasia“, receptive aphasia)



normal

Well this is .... mother is away here working her work out o'here to get her better, but when she's looking, the two boys looking in other part. One their small tile into her time here. She's working another time because she's getting, too.

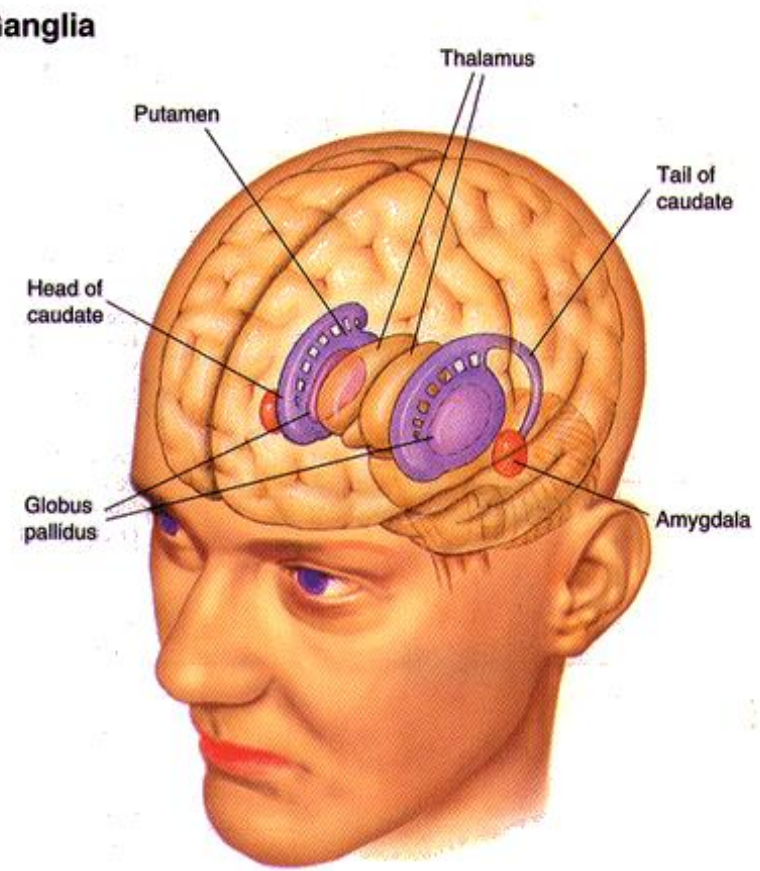


Occipital Lobe

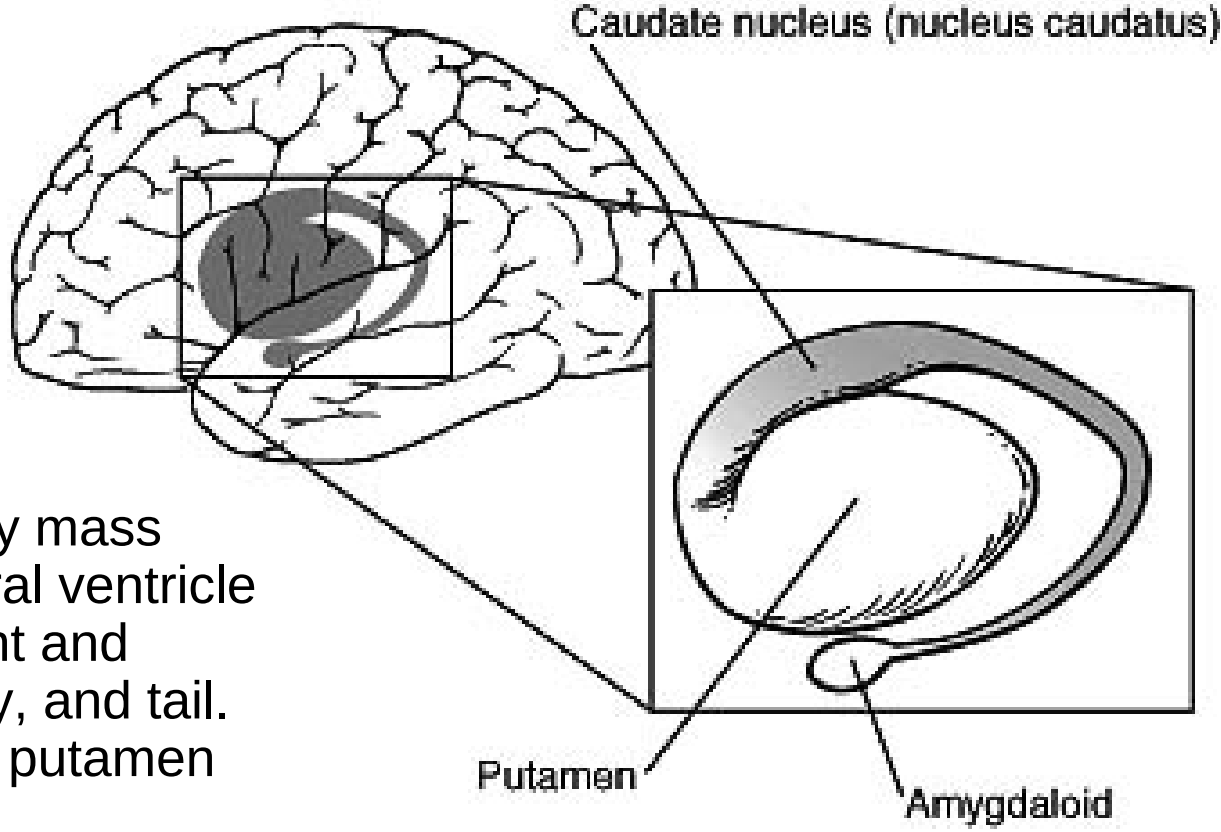
It is crucial for the sense of sight.

Basal Ganglia: Subcortical Nuclei Involved in Movement

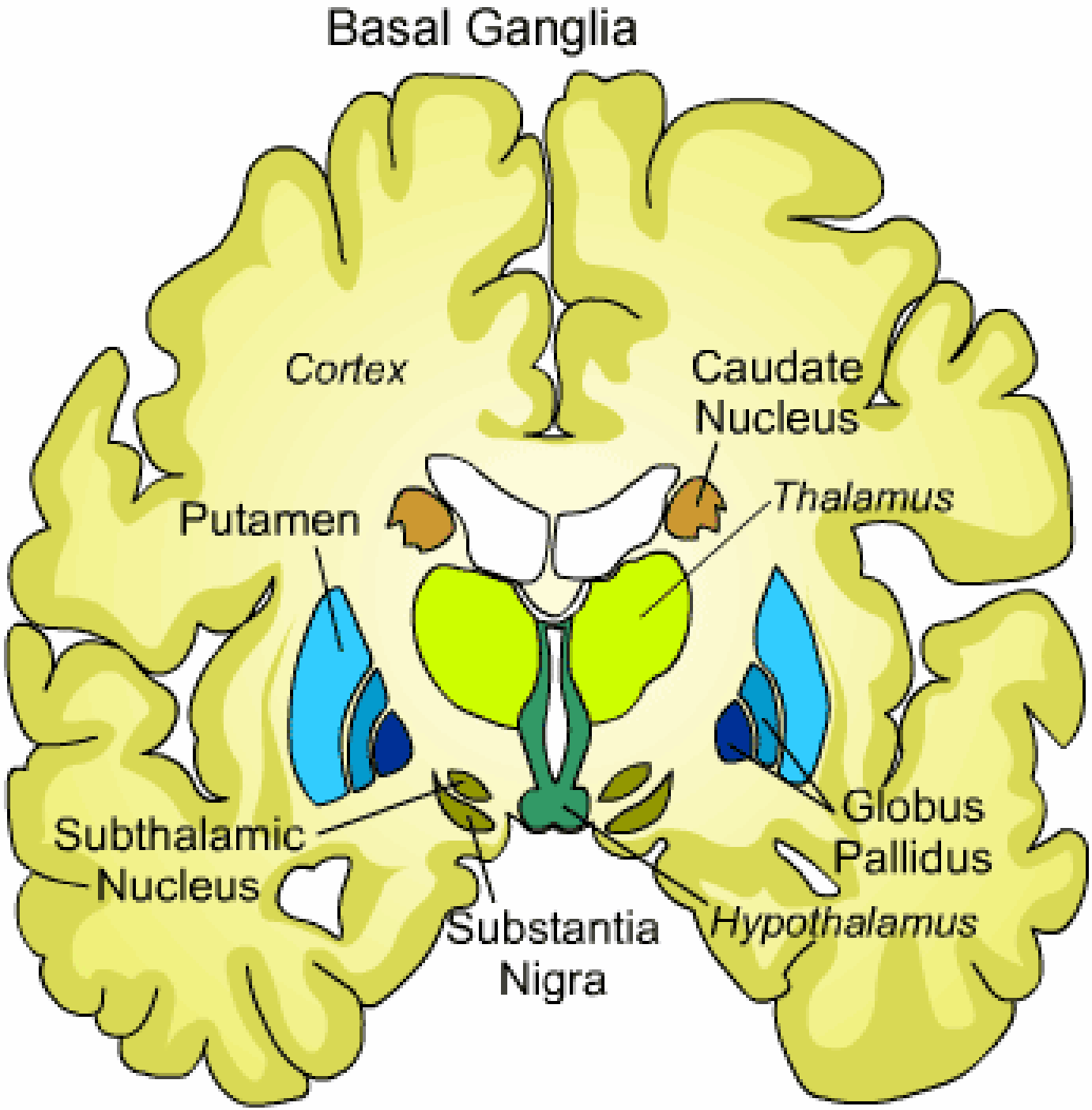
- **A group of nuclei lying deep in the subcortical white matter of the frontal lobes that organizes muscle driven motor movements of the body behavior.**
- **The caudate, putamen, and the globus pallidus are the major components.**
- **Functionally associatied with the subthalamic nucleus (located in the lateral floor of the diencephalon) and the substantia nigra (in midbrain) are often included.**



Caudate Nucleus



- An elongated, arched gray mass closely related to the lateral ventricle throughout its entire extent and consisting of a head, body, and tail. The caudate nucleus and putamen form a functional unit (the **neostriatum**) of the corpus striatum that control voluntary movement.
- The caudate organizes and filters information that is sent to the frontal lobe, particularly information from the limbic system.



- **striatum** (caudate + putamen + nucleus accumbens),
- **the corpus striatum** (striatum + globus pallidus), or
- **the lenticular nucleus** (putamen + globus pallidus)

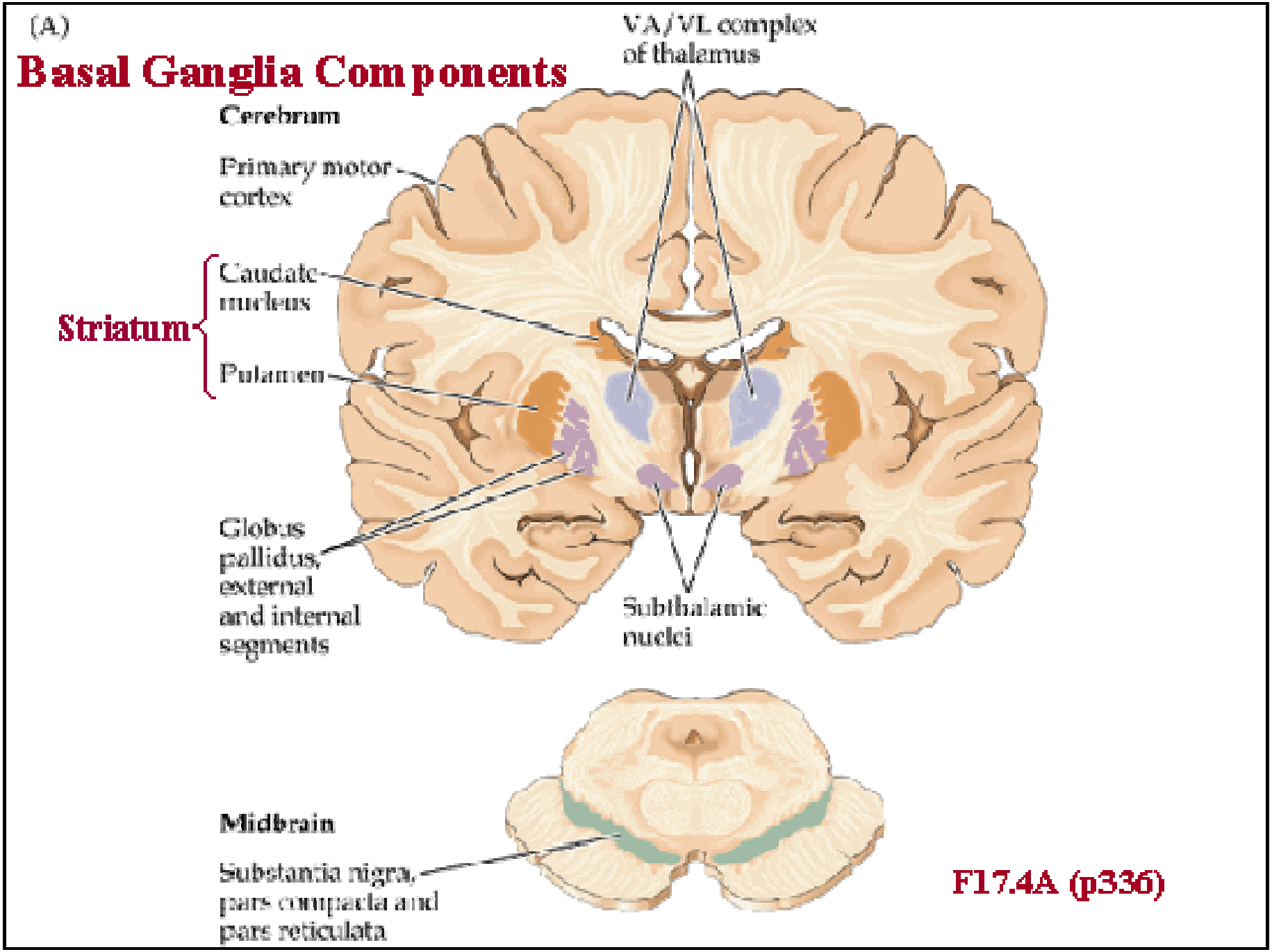
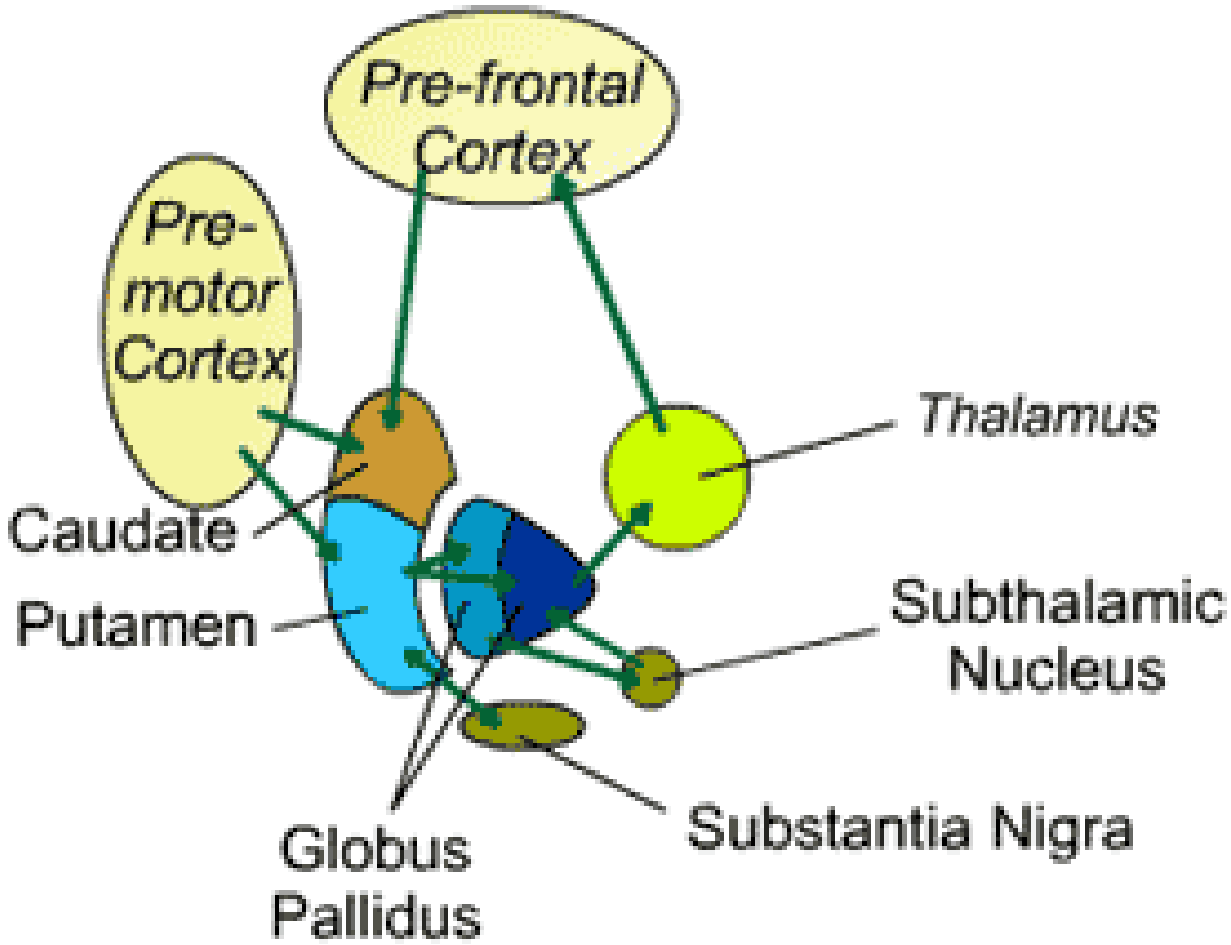

(A)
Basal Ganglia Components
VA/VL complex of thalamus
Cerebrum
Primary motor cortex
Striatum
Caudate nucleus
Putamen
Globus pallidus, external and internal segments
Subthalamic nuclei
Midbrain
Substantia nigra, pars compacta and pars reticulata
F17.4A (p336)

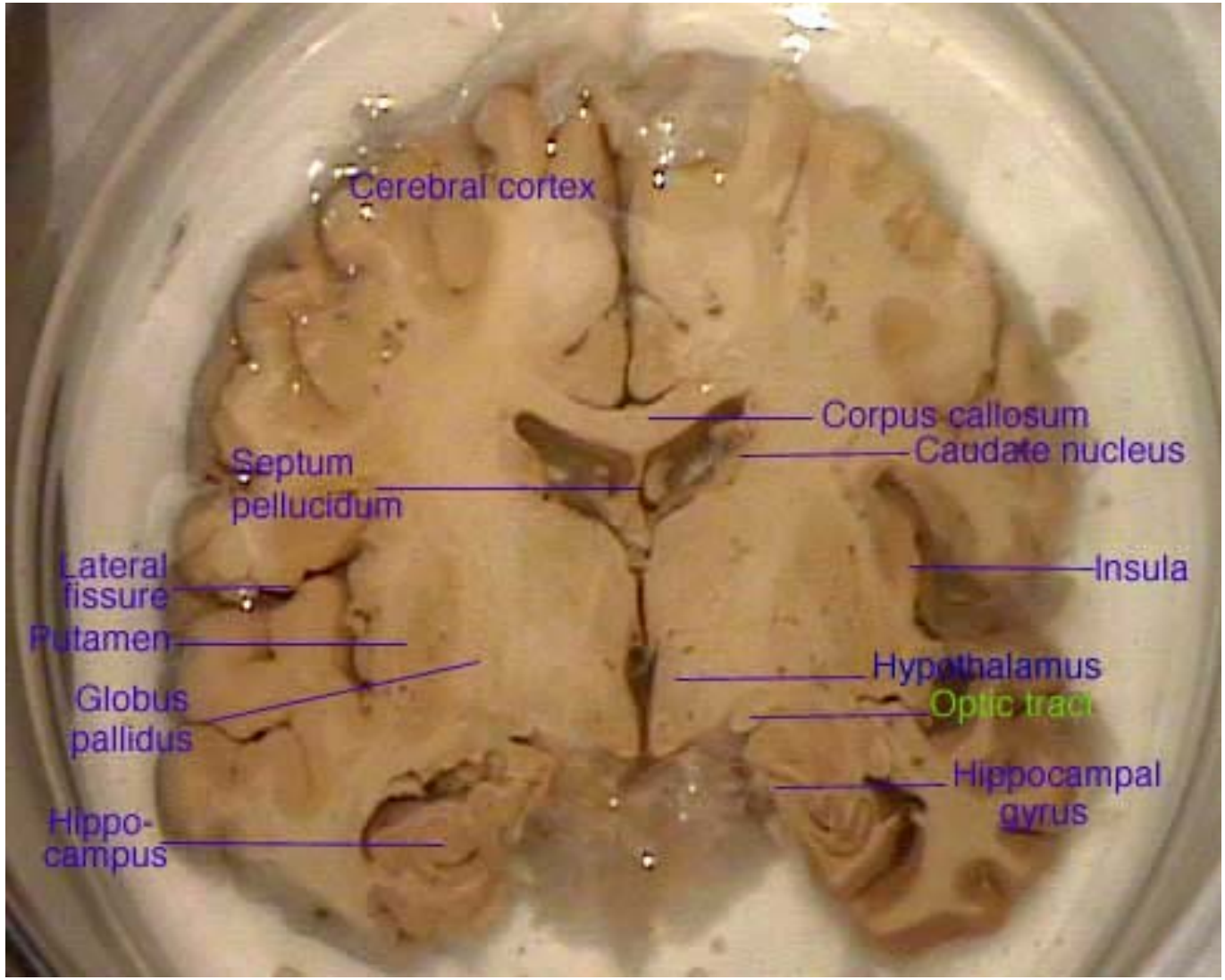
Figure AB-19: Basal Ganglia Pathways



Neostriatum = Caudate + Putamen

Striatum = Caudate + Putamen + Globus Pallidus

Diagram colors are consistent with Figure AB-18.


Cerebral cortex
Corpus callosum
Caudate nucleus
Septum pellucidum
Lateral fissure
Insula
Putamen
Hypothalamus
Optic tract
Globus pallidus
Hippocampal gyrus
Hippo-campus

Brain

SUBCORTICAL STRUCTURES

BASAL GANGLIA

- Striatum
  - Caudate
  - Putamen
- Globus Pallidus

THALAMUS

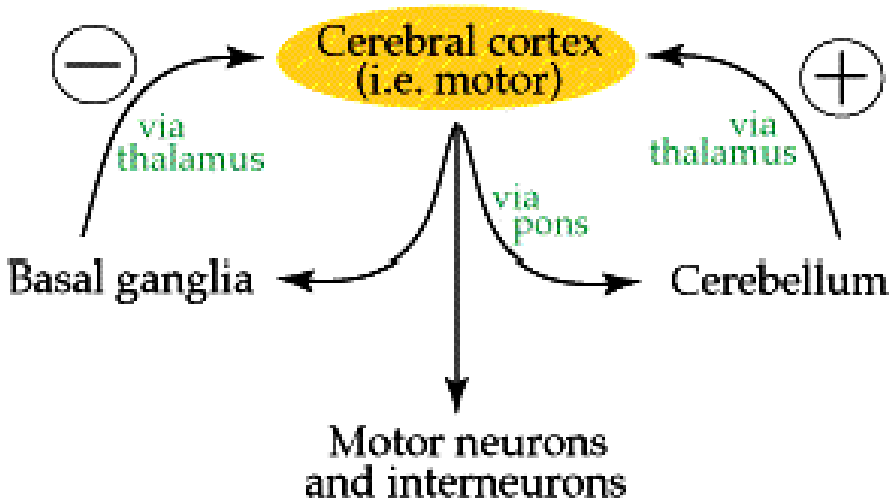
Note: Collectively the putamen & globus pallidus are referred to as the lentiform or lenticular nucleus.

POSTERIOR LIMB INTERNAL CAPSULE (PLIC)

A lesion to the PLIC will produce both contralateral sensory and motor deficits. The descending motor paths pass through it and the ascending sensory, thalamocortical fibers ascend in it. However, aphasias will not be involved.

Basal Ganglia

- The basal ganglia and cerebellum are large collections of nuclei that modify movement on a minute-to-minute basis.
- Motor cortex sends information to both, and both structures send information right back to cortex via the thalamus. (Remember, to get to cortex you must go through thalamus.)
- The output of the cerebellum is excitatory, while the basal ganglia are inhibitory. The balance between these two systems allows for smooth, coordinated movement, and a disturbance in either system will show up as movement disorders.



Basal Ganglia

Responsible for:

- Selecting and maintaining **purposeful motor activity** while suppressing unwanted or useless movement.
- Helping monitor and coordinate **slow, sustained contractions** related to posture and support.
- **Inhibiting muscle tone** throughout the body (proper muscle tone is normally maintained through a balance of excitatory and inihibtory inputs to the neurons that inervate skeletal muscle).
- Although there are many different neurotransmitters used within the basal ganglia (principally ACh, GABA, and dopamine)

Basal Ganglia

- The function of the basal ganglia is often described in terms of a "brake hypothesis".
- To sit still, you must put the brakes on all movements except those reflexes that maintain an upright posture.
- To move, you must apply a brake to some postural reflexes, and release the brake on voluntary movement.
- In such a complicated system, it is apparent that small disturbances can throw the whole system out of whack, often in unpredictable ways.
- The deficits tend to fall into one of two categories:
  - the presence of extraneous unwanted movements
  - or an absence or difficulty with intended movements.

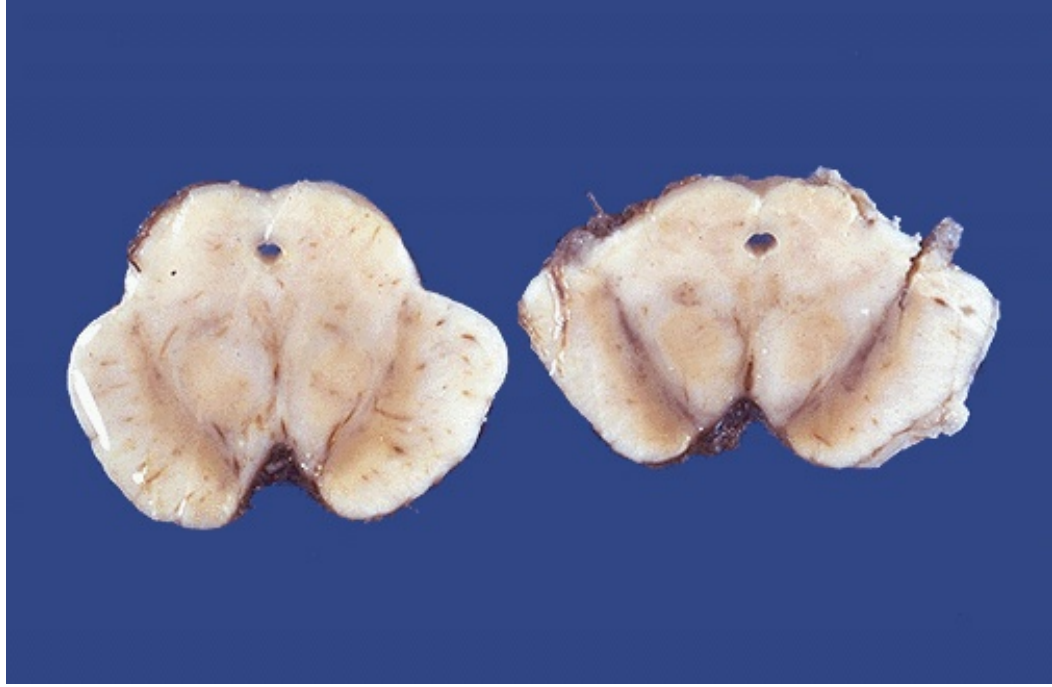
Lesions of the Basal Ganglia

Parkinson's disease,

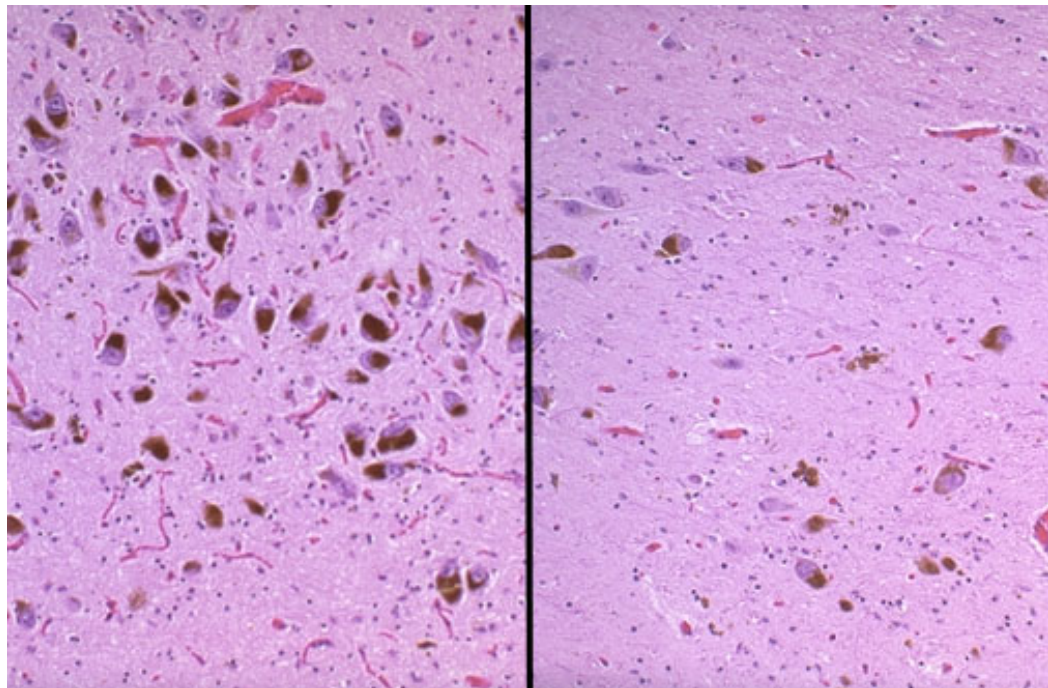
- results from the slow and steady loss of dopaminergic neurons in Substantia nigra pars compacta (SNpc).
- The three symptoms usually associated with Parkinson's are **tremor**, **rigidity**, and **bradykinesia**.
  - The tremor is most apparent at rest.
  - Rigidity is a result of simultaneous contraction of flexors and extensors, which tends to lock up the limbs.
  - Bradykinesia, or "slow movement", is a difficulty initiating voluntary movement, as though the brake cannot be released.

gait_ab_05.mov

- A normally pigmented substantia nigra is seen grossly in the midbrain on the right, but the midbrain on the left from the patient with Parkinson's disease shows a pale substantia nigra.



A normally pigmented substantia nigra is seen on the left, but the patient with Parkinson's disease has decreased neurons and pigment as seen microscopically at the right.



Lesions of the Basal Ganglia

Huntington's disease, or **chorea**

- is a hereditary disease of unwanted movements.
- It results from degeneration of the caudate and putamen,
  - and produces continuous dance-like movements of the face and limbs.
- A related disorder is **hemiballismus**,
  - flailing movements of one arm and leg, which is caused by damage (i.e., stroke) of the subthalamic nucleus.

Choreiform Gait Demonstration

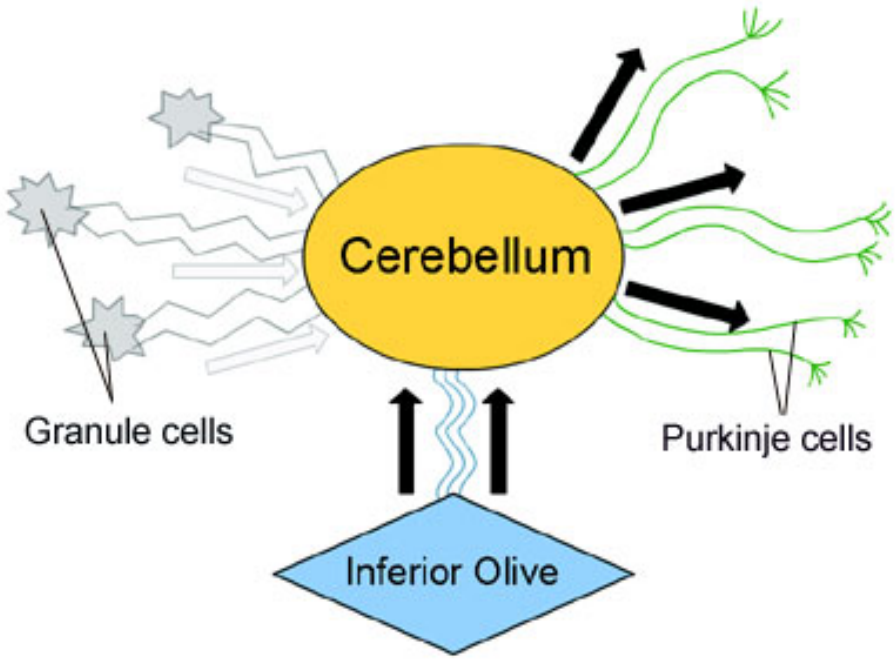
- This is a hyperkinetic gait seen with certain types of basal ganglia disorders. There is intrusion of irregular, jerky, involuntary movements in both the upper and lower extremities.

Cerebellum

- the largest part of the hind brain
- consist of
  - cerebellar hemisphers connected by a narrow bridge-like vermis
  - three pairs of stalks, cerebellar peduncles connect the crebellum to the brainstem
    - inferior peduncle to the medulla oblongata
    - middle peduncle to the pons
    - superior peduncle to the midbrain
  - the peduncles are nerve fibers that carry all signals between the cerebellum and the rest of the brain
- Receives most of its input from the pons
- Spinocerebellar tracts enter through the inferior peduncle
- Motor output leaves the cerebellum through the superior peduncle

- The cerebellum is known to be the place in the brain where learned movements are stored, therefore, it has a large amount of control over the coordination of movements
- the cerebellum receives input from various other parts of the brain (and spinal cord).
- One such brain part is called the inferior olive, which itself receives sensory information from many parts of the brain and spinal cord.
- It then relays this info to the cerebellum.
- In the cerebellum, the data are analyzed and a course of action is quickly decided.
- Each and every piece of information that leaves the cerebellum does so through the **Purkinje cells**.
- symptom of damage is ataxia (including the loss of coordination and difficulty with speech) begin to show.

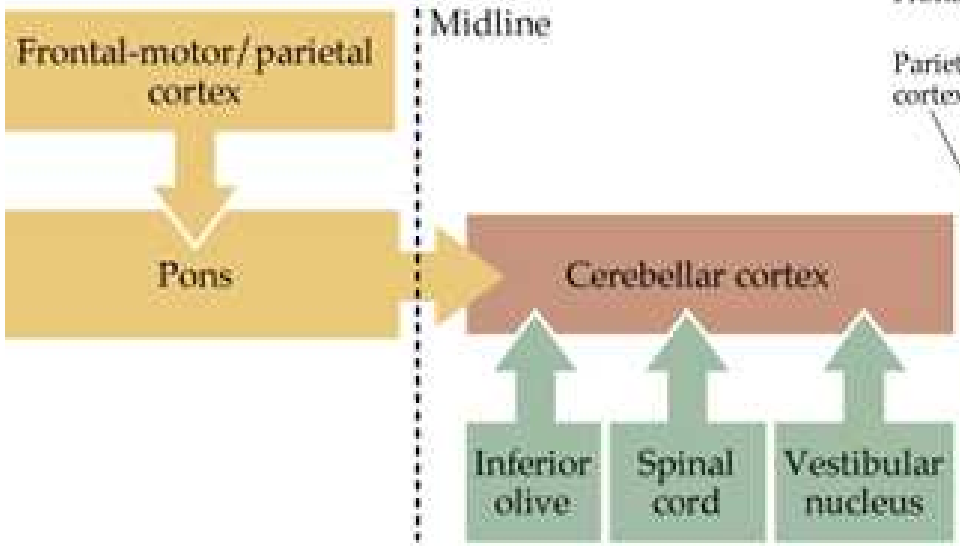
Figure F-8: Inferior Olive & Purkinje Cells

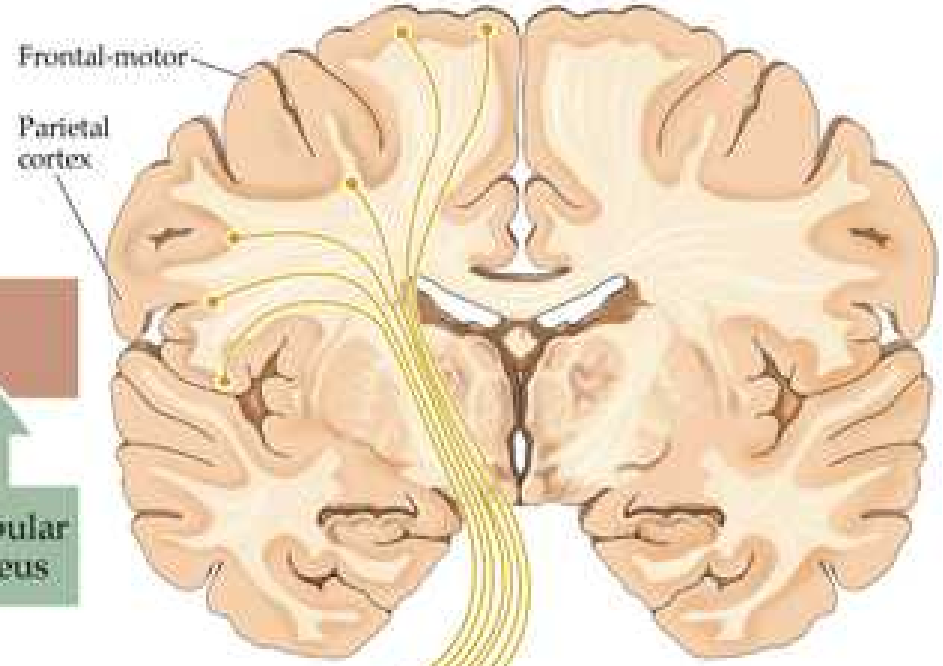


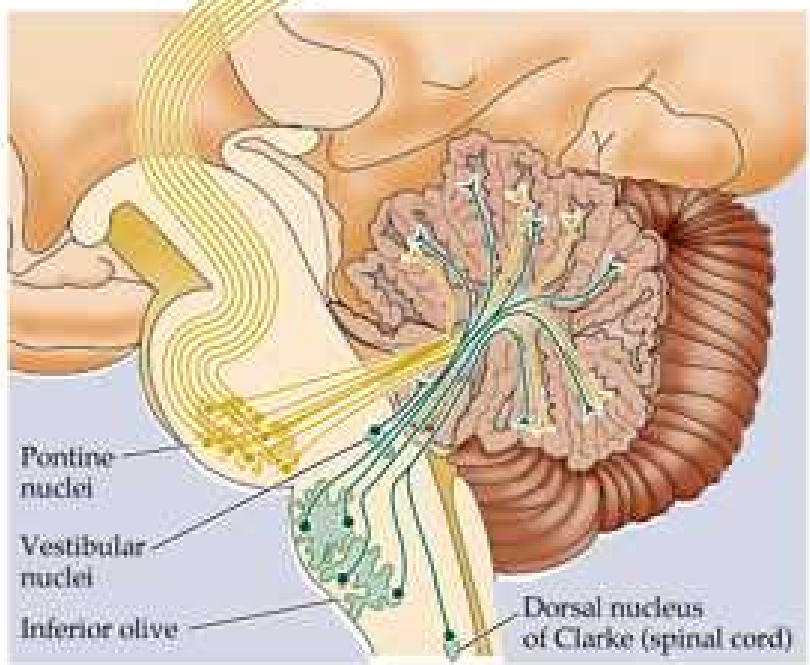
The inferior olive inputs sensory information to the cerebellum, and the Purkinje cells communicate the output.

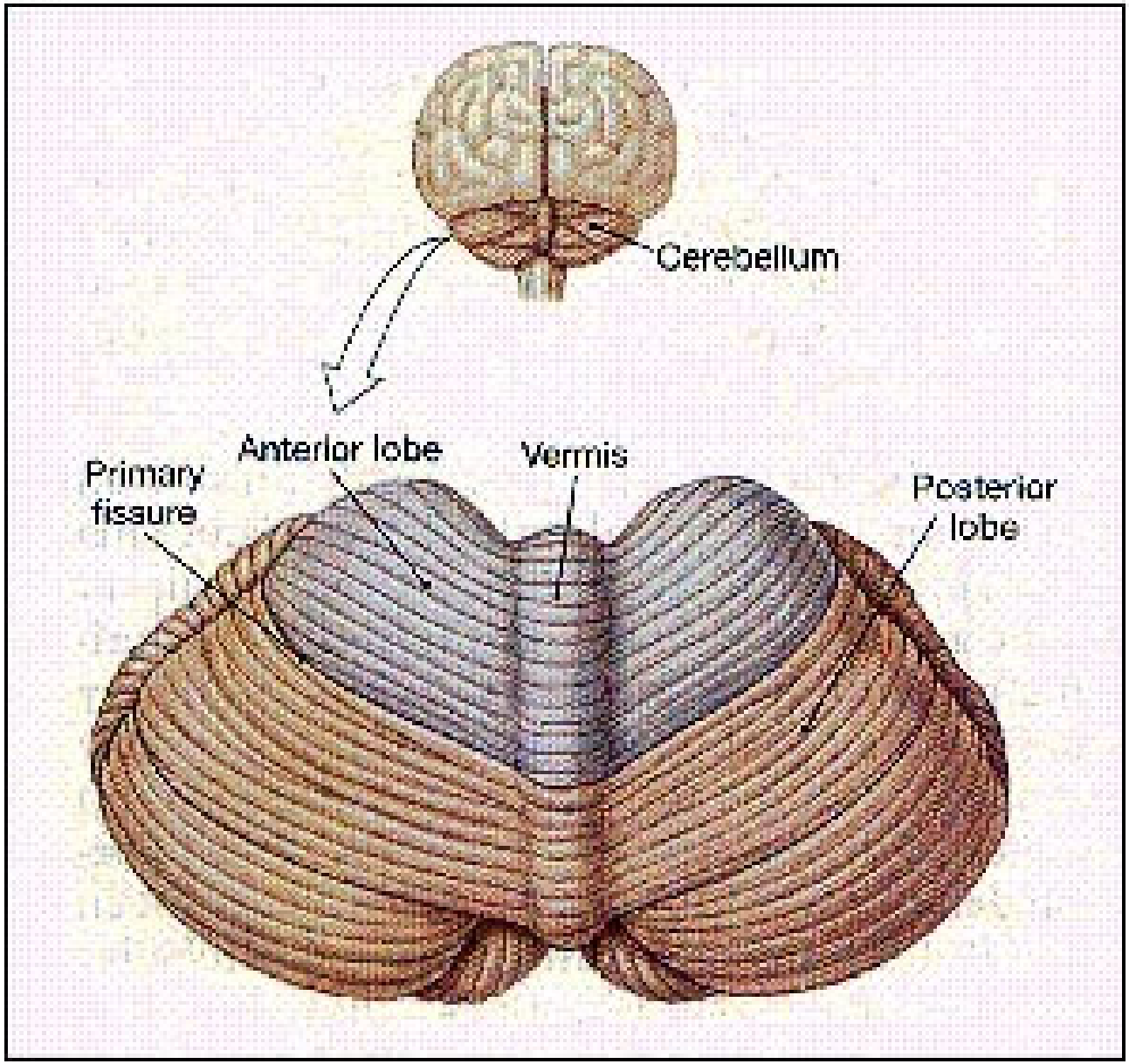
tandem gait

finger-nose


Frontal-motor/parietal cortex
Midline
Pons
Cerebellar cortex
Inferior olive
Spinal cord
Vestibular nucleus


Frontal-motor
Parietal cortex


Pontine nuclei
Vestibular nuclei
Inferior olive
Dorsal nucleus of Clarke (spinal cord)


Cerebellum
Anterior lobe
Vermis
Primary fissure
Posterior lobe

- Each hemisphere exhibits slender, parallel folds called folia (gyri) separated by shallow sulci
- Has a cortex of gray matter and a deeper layer of white matter called arbor vitae which exhibits branching and a fern-like pattern

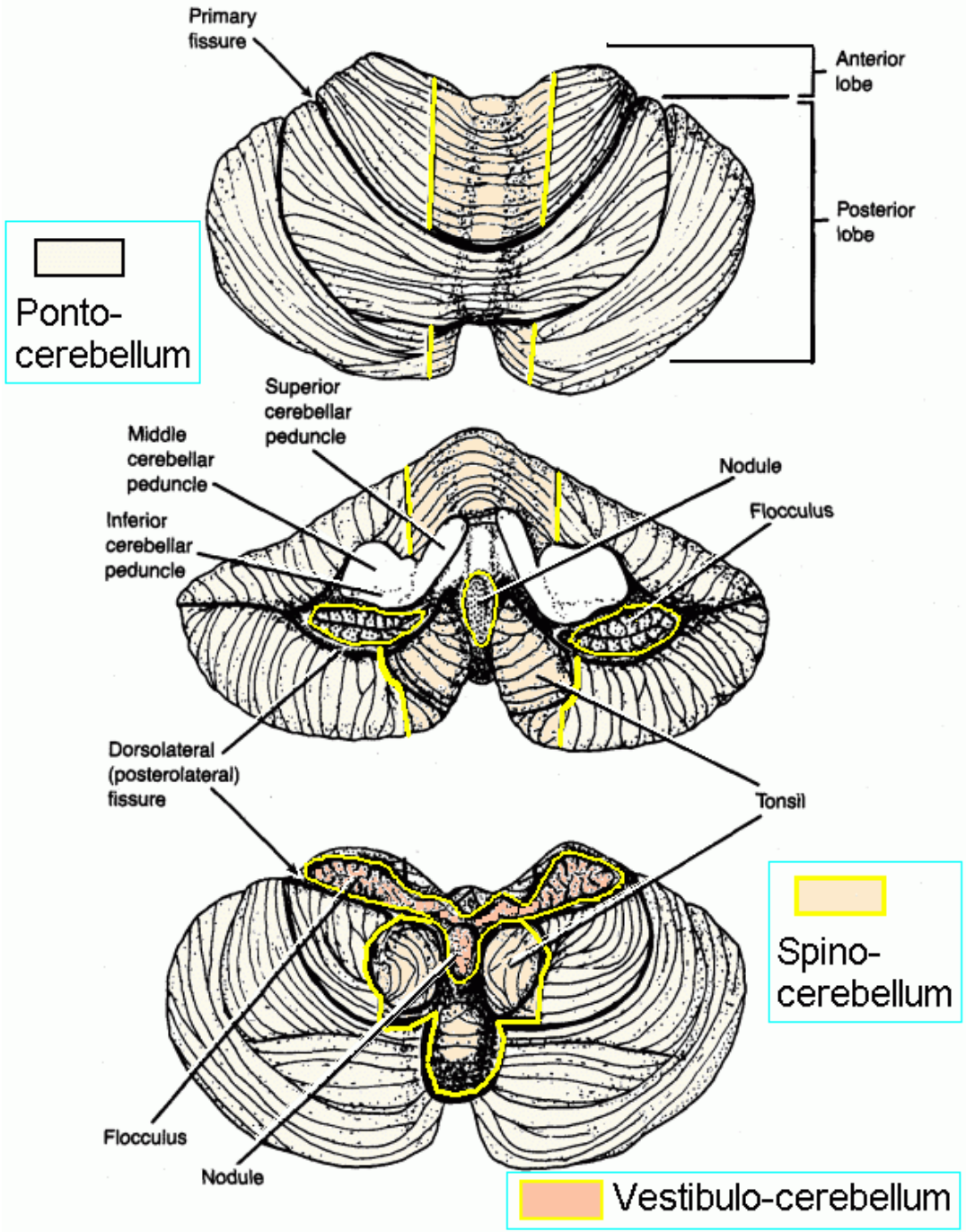
Lobules of Vermis

1	Lingula
2	Central lobule
3	Culmen
4	Declive
5	Folium
6	Tuber
7	Pyramis
8	Uvula
9	Nodulus

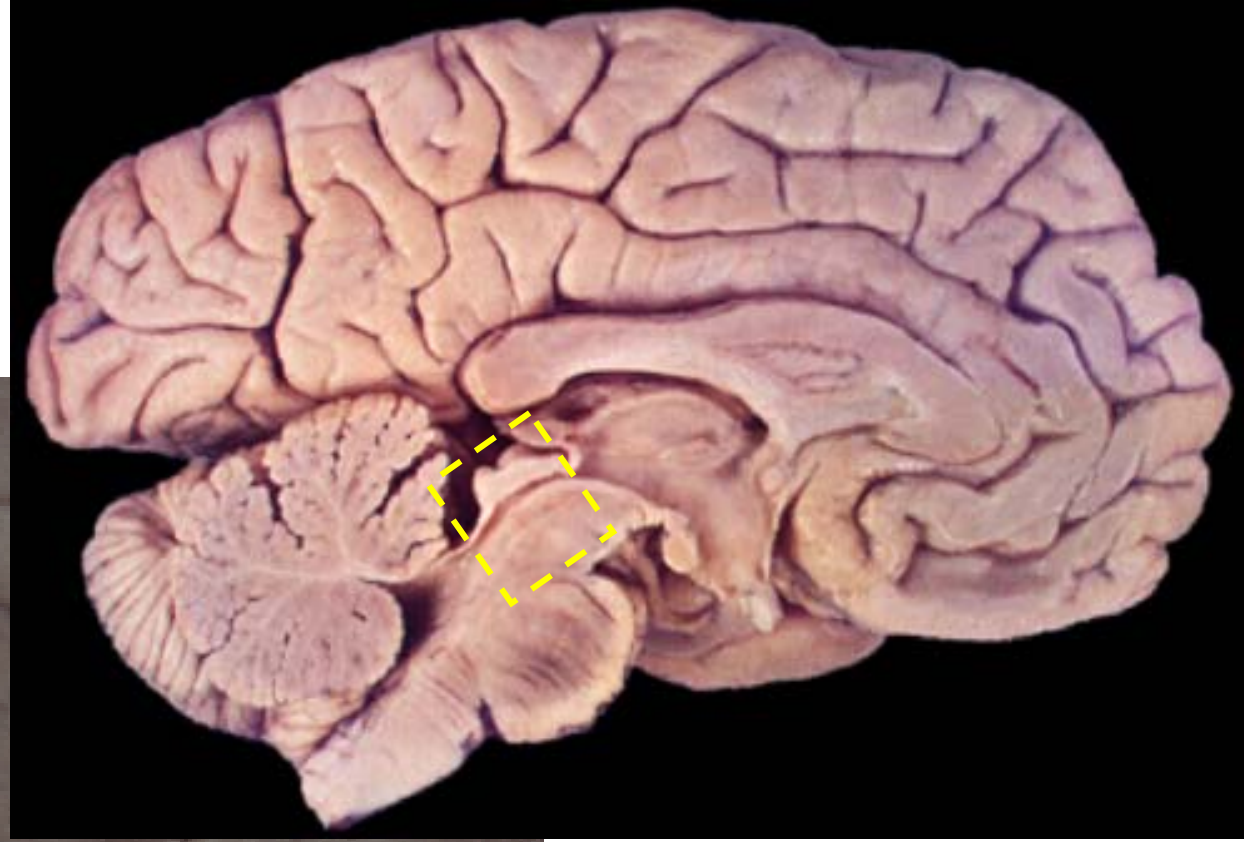
Brainstem Anatomy

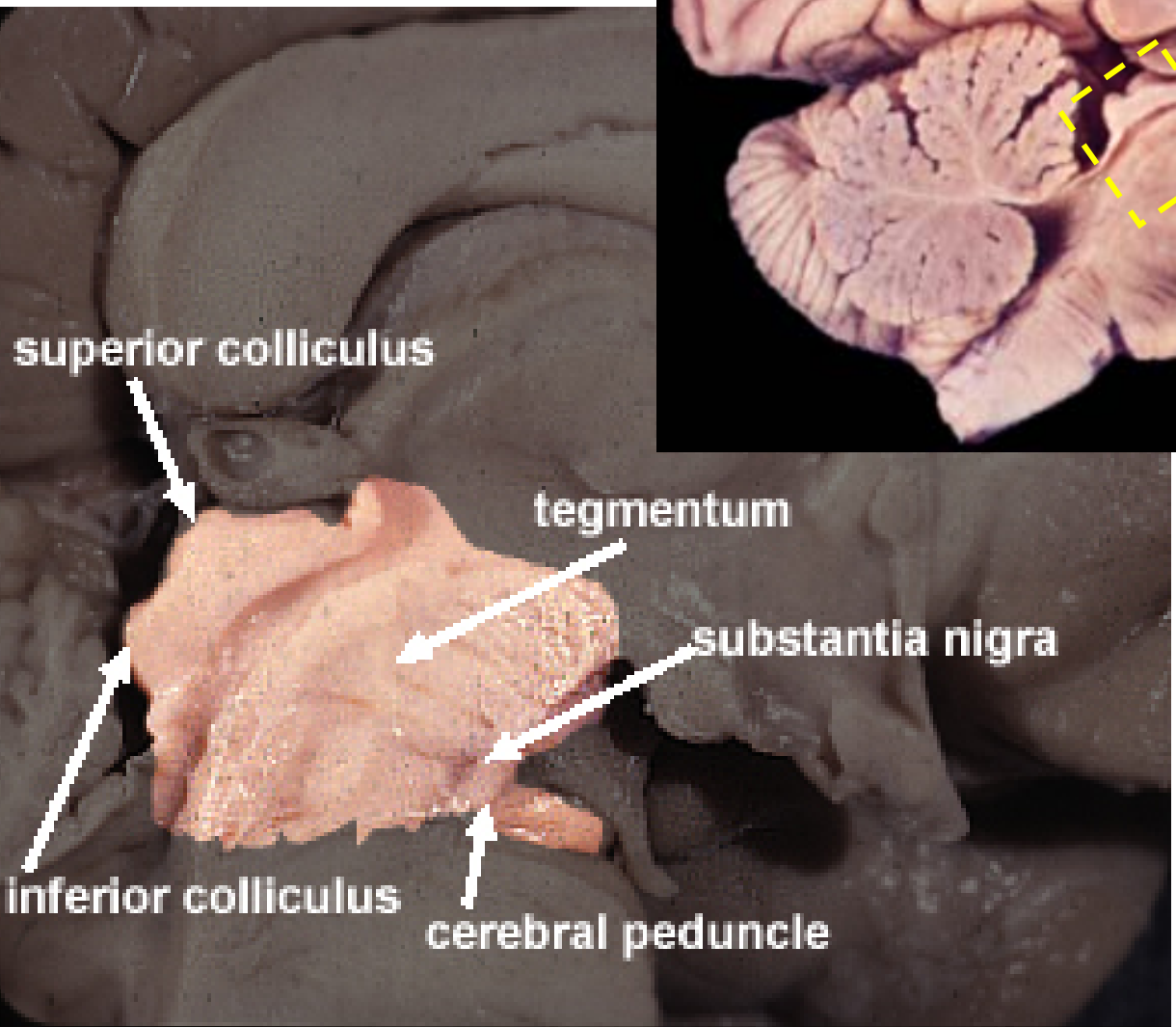
A	Midbrain
B	Pons
C	Medulla
D	Cerebral aquaduct
E	Fourth ventricle
F	Primary fissure
G	Posterolateral fissure

Landmarks and functional divisions of the cerebellum

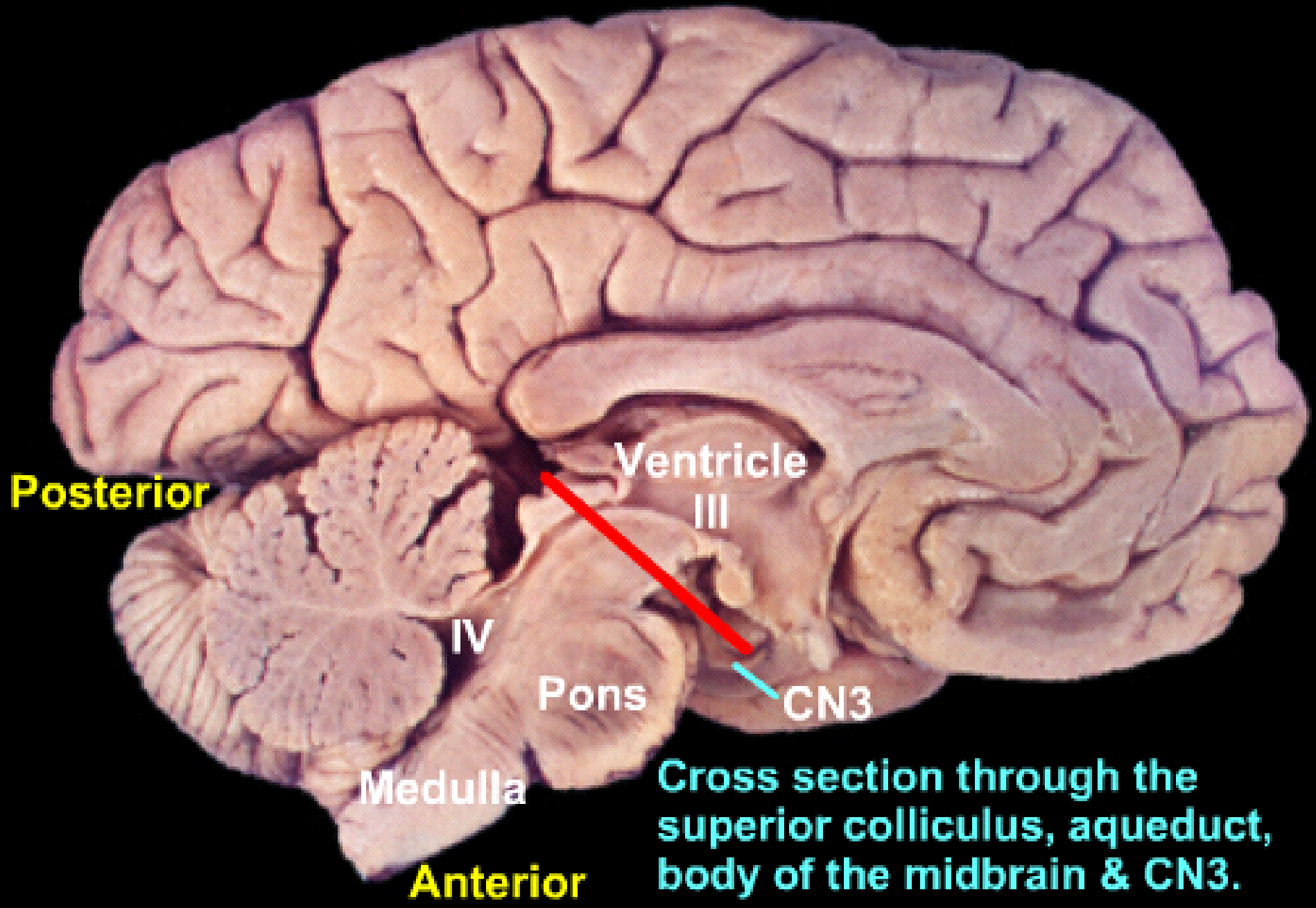


Midbrain

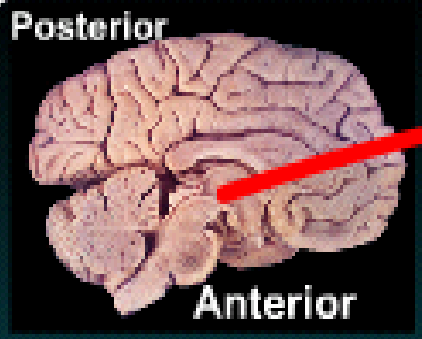



superior colliculus
tegmentum
substantia nigra
inferior colliculus
cerebral peduncle

LEVEL OF THE MIDBRAIN CROSS SECTION



Cross section through the superior colliculus, aqueduct, body of the midbrain & CN3.



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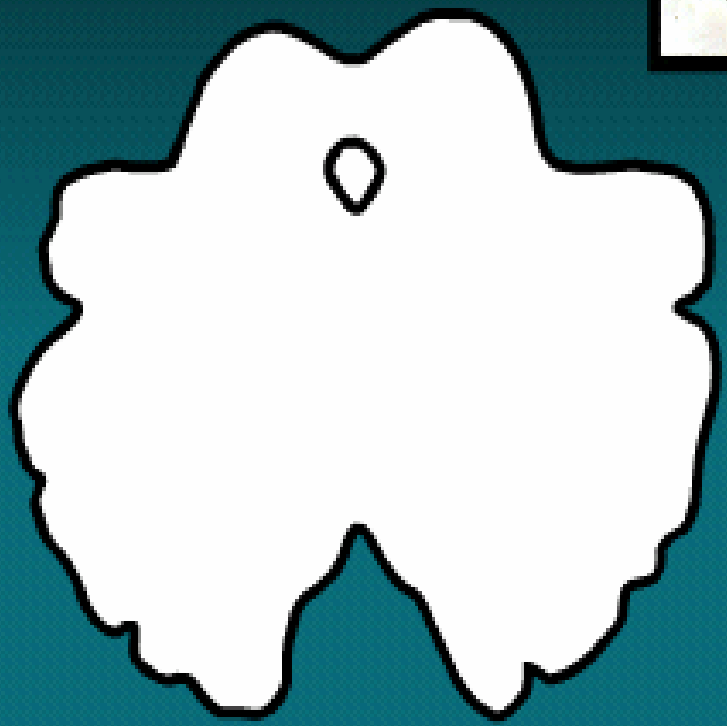
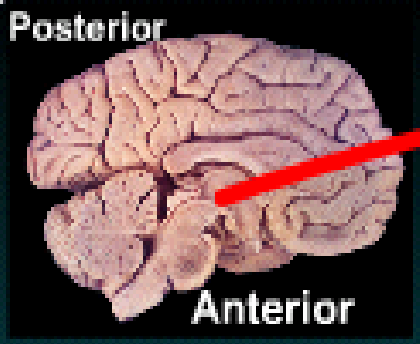


Superior Colliculus Level of the Midbrain



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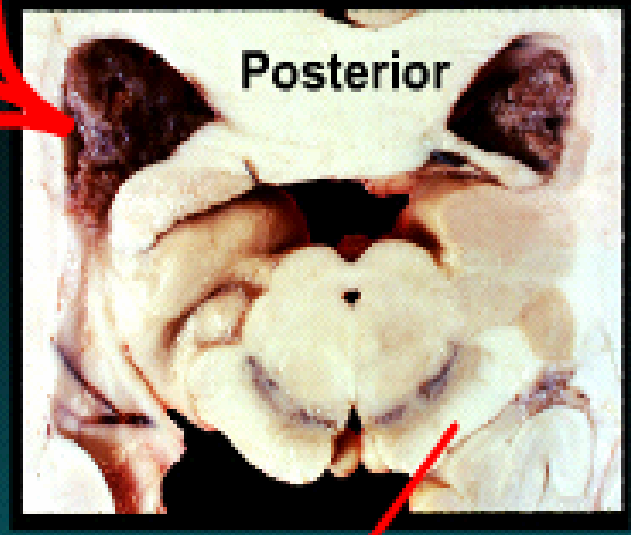
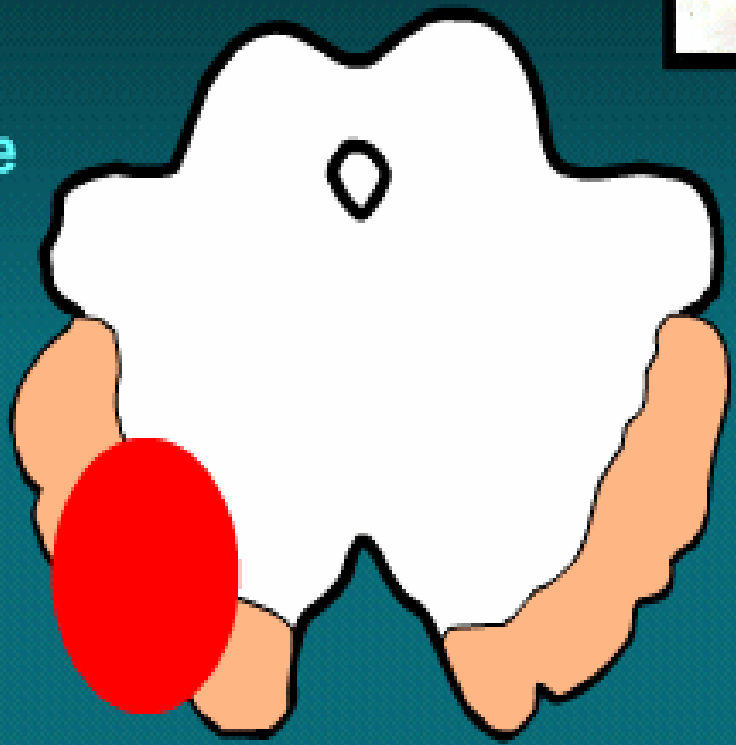
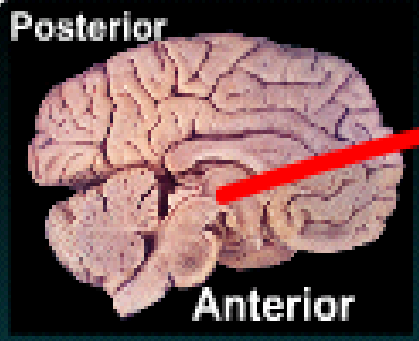


Contralateral upper motor neuron symptoms to the face & body:

- Babinski Sign
- Increased DTRs
- Hypertonia
- Spasticity
- Hyperreflexia
- Weakness
- No atrophy (except disuse)



Cerebral Peduncle White matter, heavily myelinated. Descending motor paths: corticospinal & corticobulbar tracts. Lesion would give rise to contra-lateral upper motor neuron signs.



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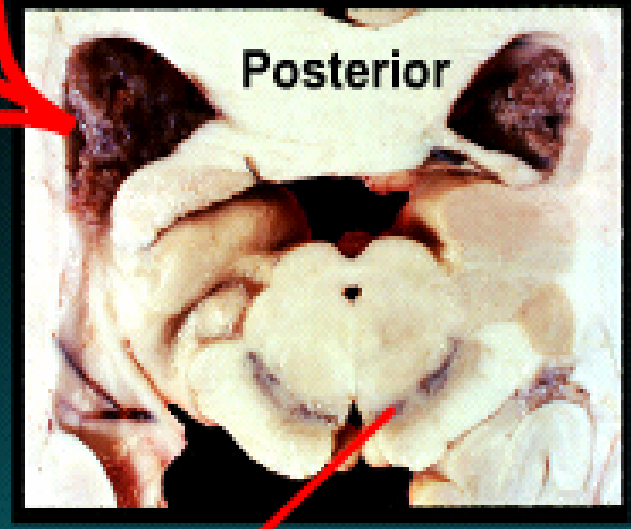
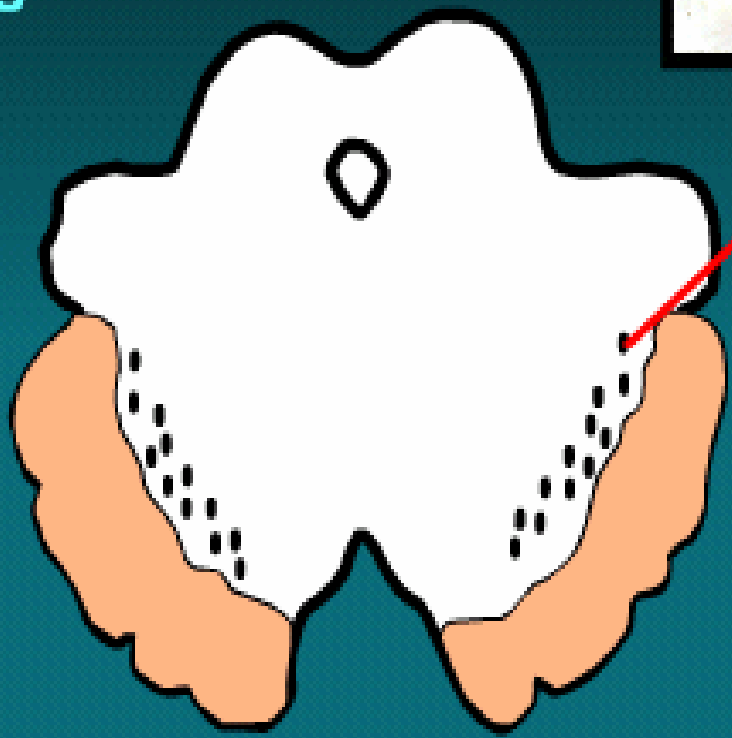
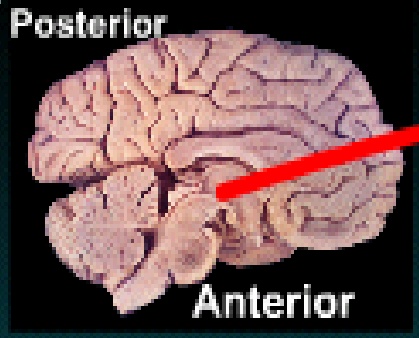


Substantia Nigra

Pigmented, neuronal population with dopaminergic neurons. Degenerates bilaterally in Parkinson's Disease.





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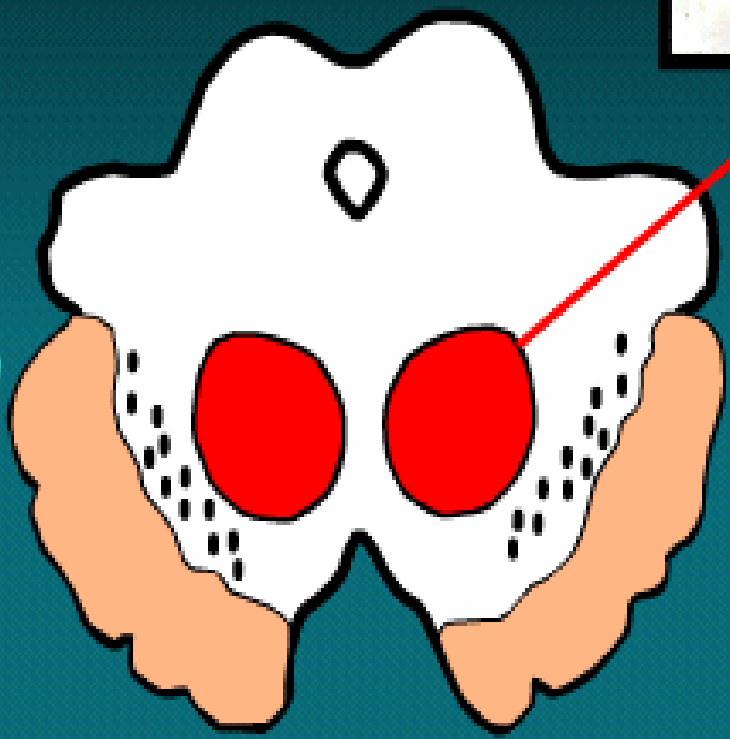
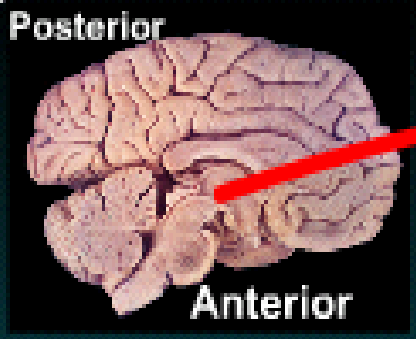
Red Nucleus

Heavily vascularized. Gives rise to a crossed pathway (rubrospinal tract) that assists the corticospinal tract.





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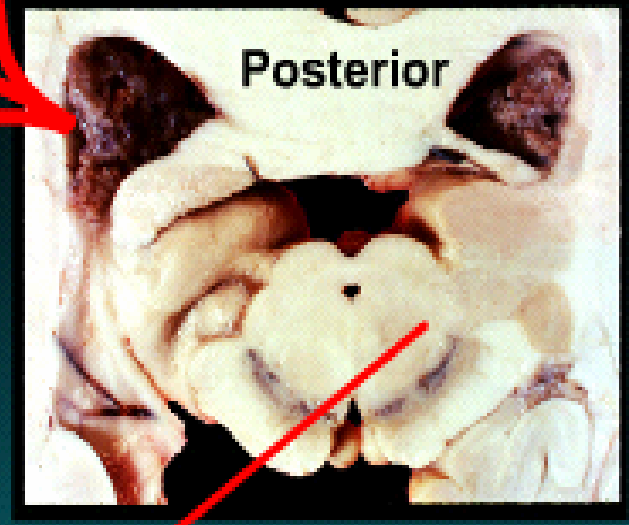
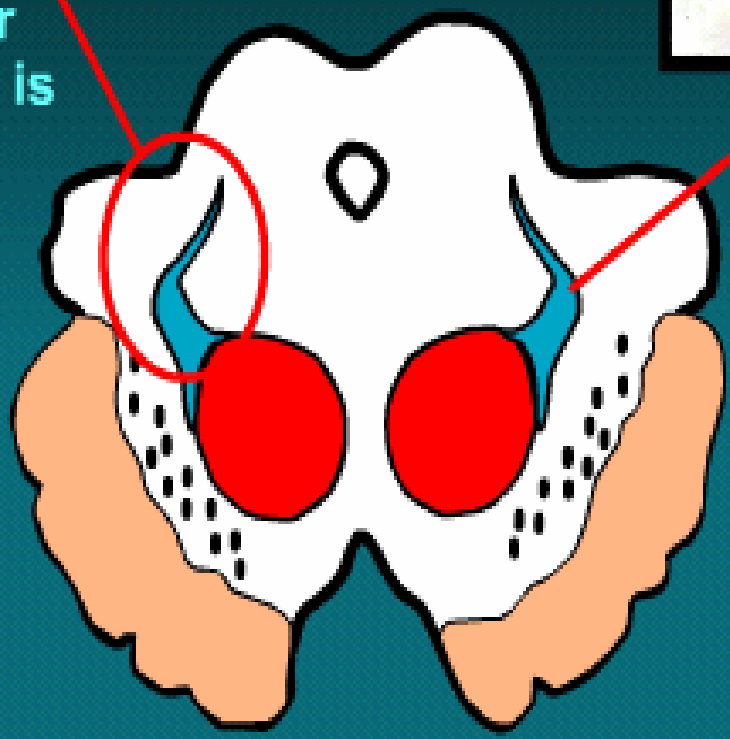


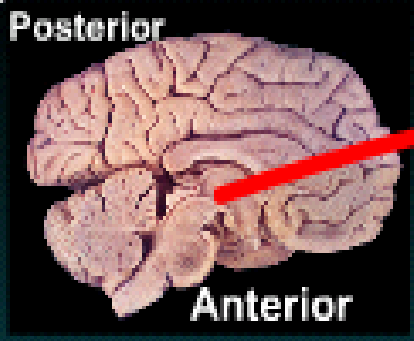
Contralateral Symptoms to the upper & lower extremities if lesion is complete:

- Loss of position sense
- Loss of vibratory sense
- Decreased fine tactile



Medial Lemniscus

Information from the post column pathways of the contralateral spinal cord.



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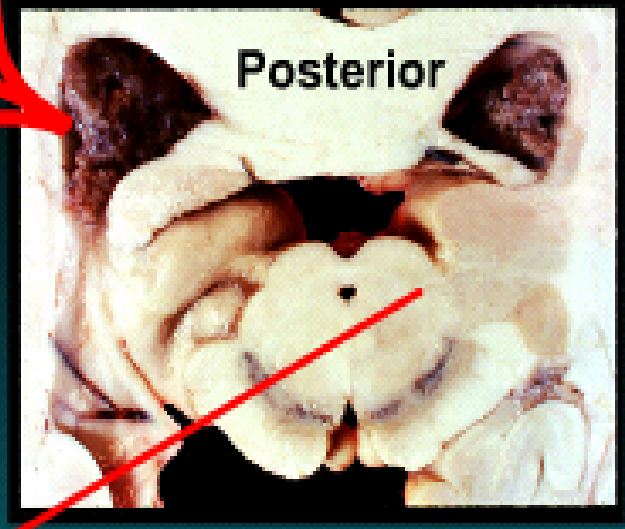
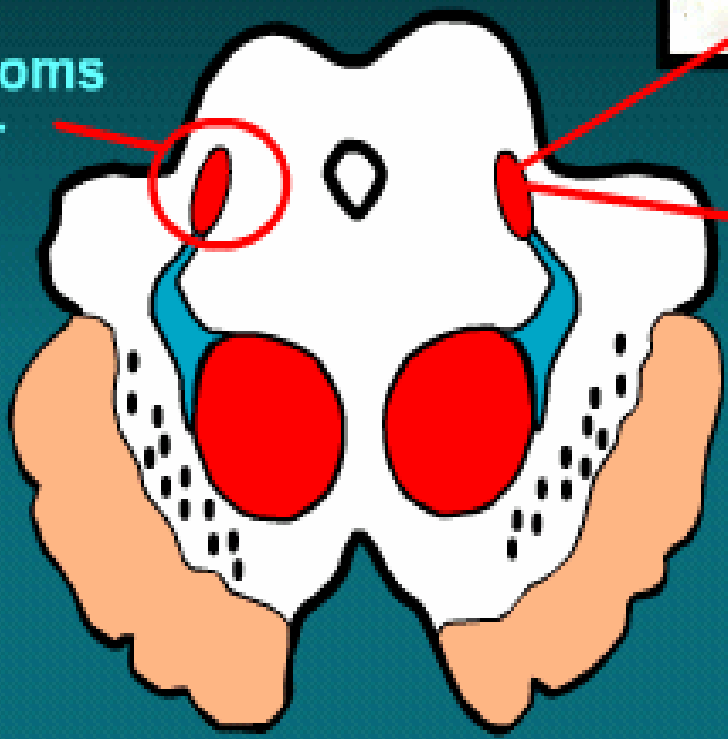
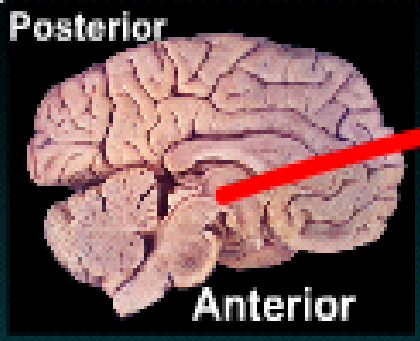


Contralateral Symptoms to the upper & lower extremities:

- Loss of pain (pinprick)
- Loss of temperature
- Loss of light touch



Spinothalamic Tract
Pain, temp, light touch from the contralateral upper & lower extremities.



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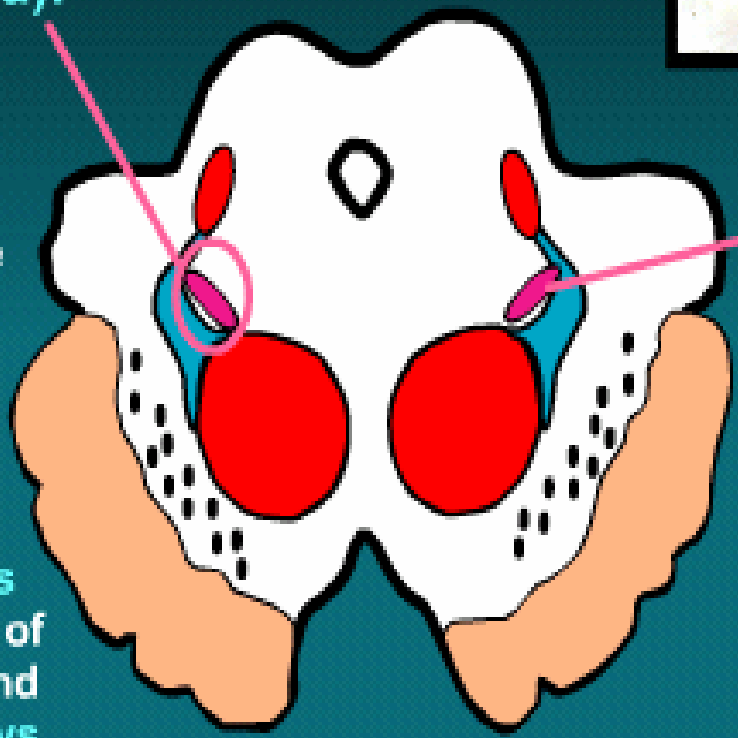
Contralateral Symptoms to the face (ant head):

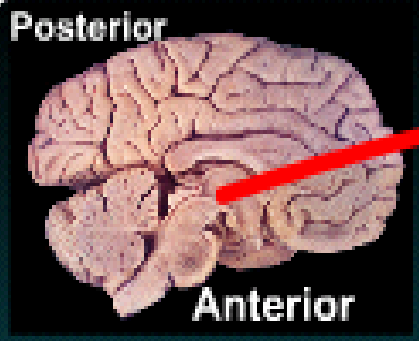
- Loss of pain (pinprick)
- Loss of temperature
- Decreased touch
- Loss position sense
- Loss of vibratory sense



Trigeminothalamic Tract

Pain, temp, light touch, fine touch, vibratory & position sense from the contralateral face.

Note: Think of the trigeminothalamic tract as subserving the functions of both the spinothalamic and posterior column pathways (medial lemniscus). But in this case it relates to the head not the body.



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Rt CN3 LESION:

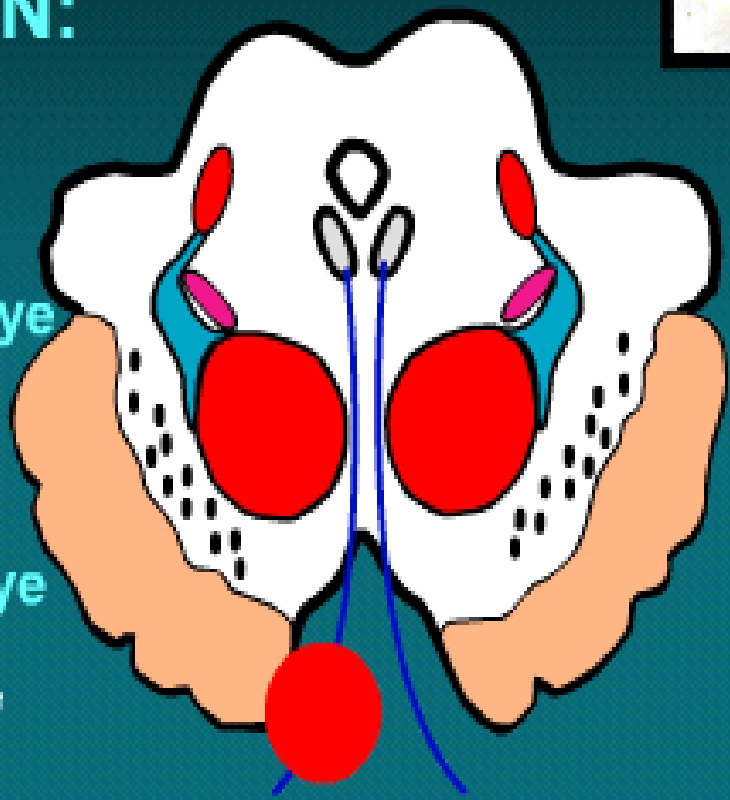
- Rt eye down & out
- Rt eye ptosis
- Diplopia

Shine light into Rt Eye

- No direct response
- + Consensual response

Shine light into Lt Eye

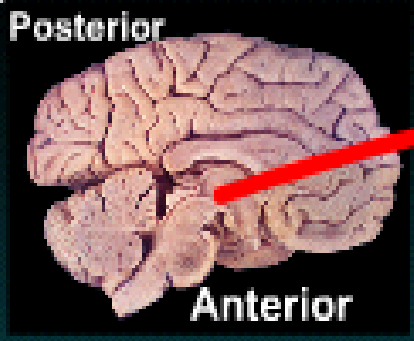
- Direct response
- No consensual response



Oculomotor Nerve

All ipsilateral extraocular muscles except sup oblique & lat rectus.

Also upper eyelid, light & accommodation reflexes.



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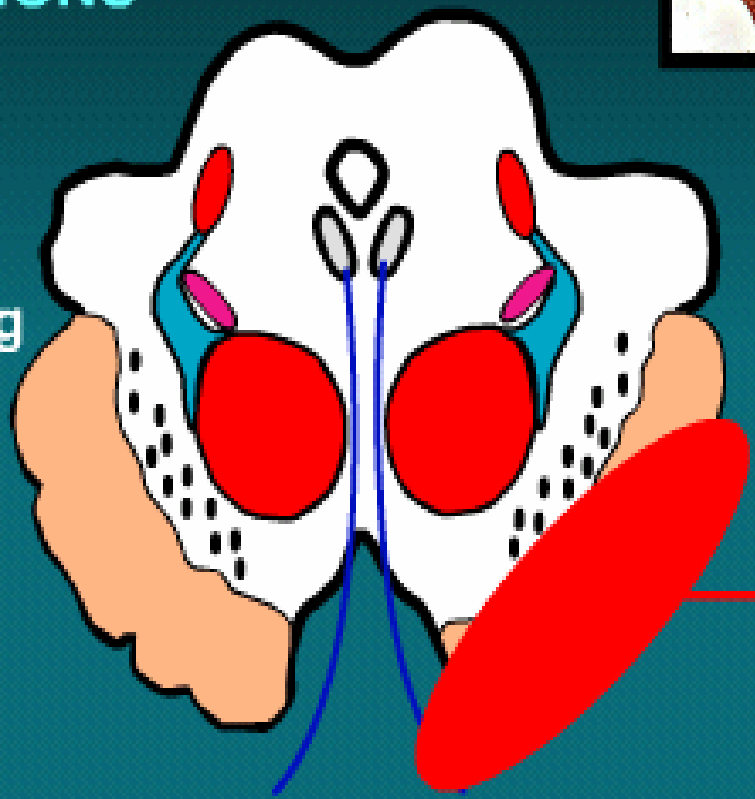
CROSSED SYNDROMES IN BRAINSTEM LESIONS

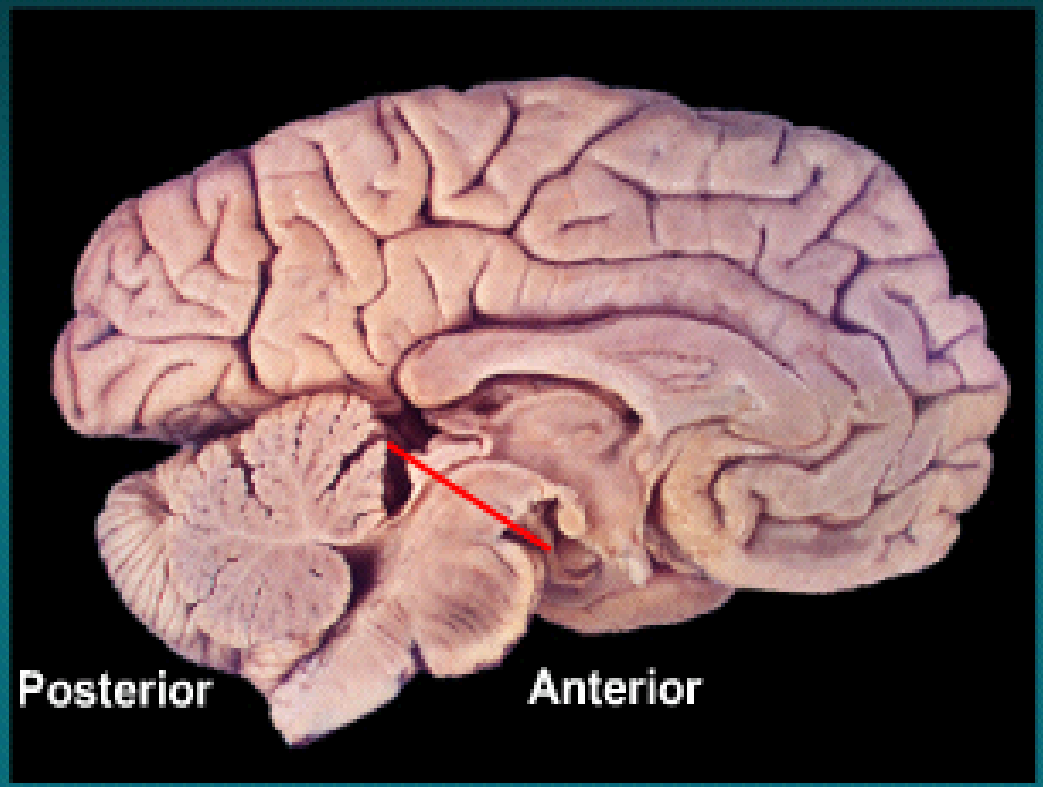
Ipsilateral cranial nerve symptoms with contralateral symptoms involving the ascending sensory and descending motor pathways.

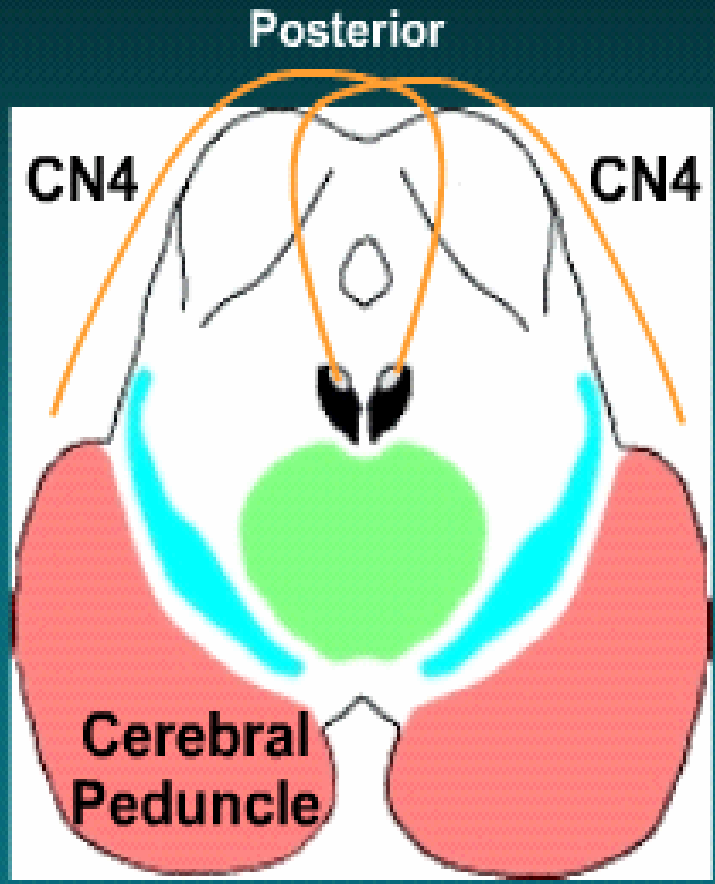


Ipsilateral CN3 symptoms with contralateral symptoms involving the corticobulbar & corticospinal paths.

The Level of the Inferior Colliculus

This is the other portion of the midbrain. It contains CN4, which innervates the contralateral inf oblique muscle. It is the only cranial nerve to decussate & to exit posteriorly.





Midbrain

- Contains the rostral end of the **reticular formation** (which results in the loss of consciousness or coma if impaired).

Tectum- rooflike region dorsal to the aqueduct consisting of the Corpora Quadrigemina

Corpora Quadrigemina (four twins)

- The dorsal or posterior part has the **superior colliculus**, which is important for visual system reflexes
- The **inferior colliculus**, which is important for auditory system function.

Midbrain

- The ventral or anterior part has the **cerebral peduncle**, which is a huge bundle of axons traveling from the cerebral cortex into/ through the brainstem; fibers are important for voluntary motor function.
- **Red nucleus-** so named because they have a pinkish color in fresh Brain specimens, because of an abundant Blood supply. The red nuclei aid in the unconscious regulation and coordination of motor activities.

Midbrain

Substantia nigra-

- A nuclear mass between the Tegmentum and Cerebral Peduncles, is a pigmented region of the midbrain with cytoplasmic Melanin Granules that give it a dark gray-to-black color.
  - has interconnections with other Basal Ganglia Nuclei of the Cerebrum and is involved in Coordinating Movement and Muscle Tone.
- Sends inhibitory signals to the thalamus and basal ganglia
- Degeneration of the neurons leads to muscle tremors of Parkinson's disease

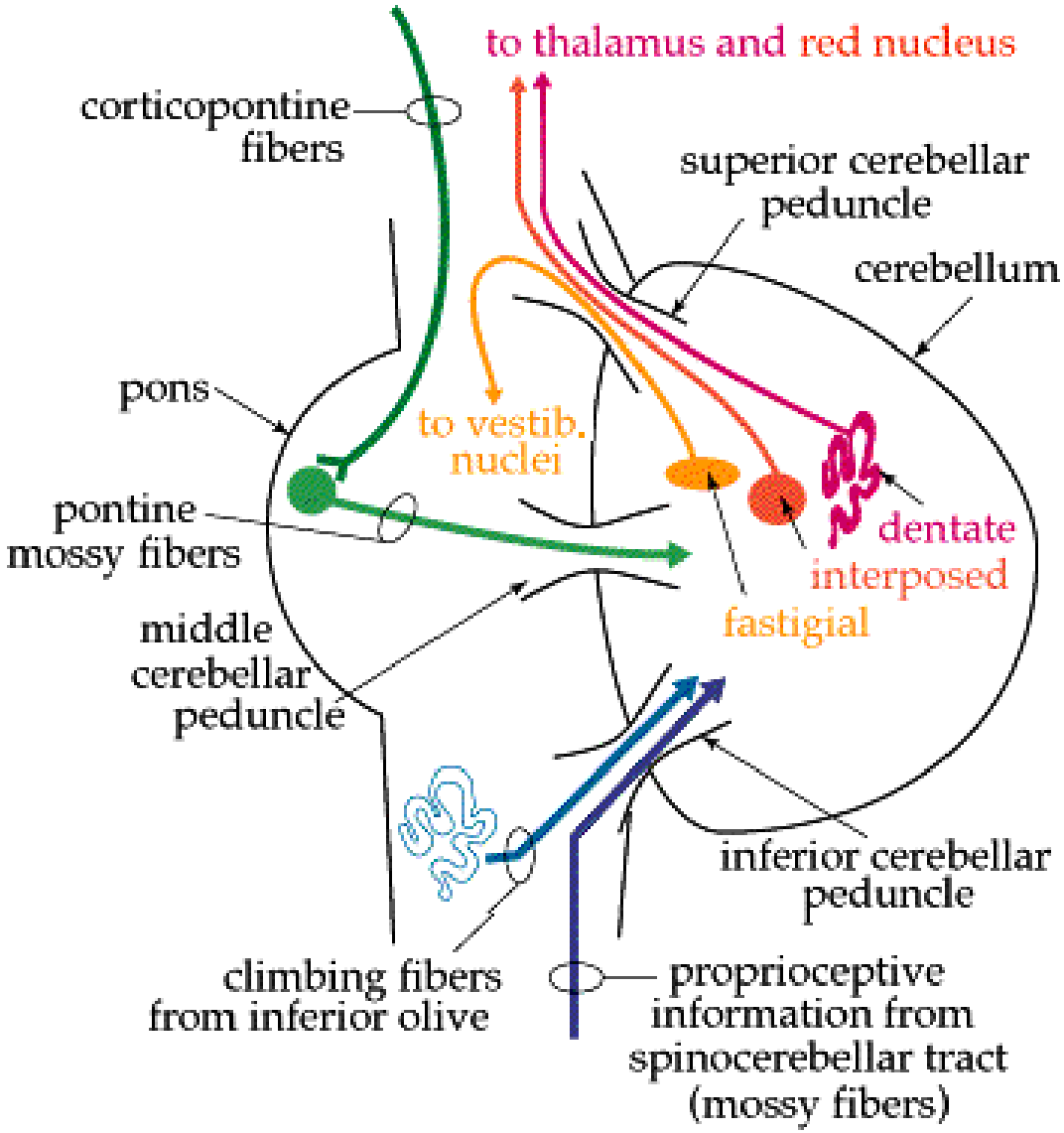
Midbrain

- **Medial lemniscus-** a continuation of the gracile and cuneate tracts of the spinal cord and brainstem
- Contains two cranial nerve nuclei that control eye movement: **Cranial Nerves III (Oculomotor) and IV (Trochlear).**

The Cerebellum ("little brain")

- The cerebellum is involved in the coordination of movement
- it compares what you thought you were going to do (according to motor cortex) with what is actually happening down in the limbs (according to proprioceptive feedback), and corrects the movement if there is a problem.
- is also partly responsible for motor learning, such as riding a bicycle.
- Unlike the cerebrum, which works entirely on a contralateral basis, the cerebellum works ipsilaterally.

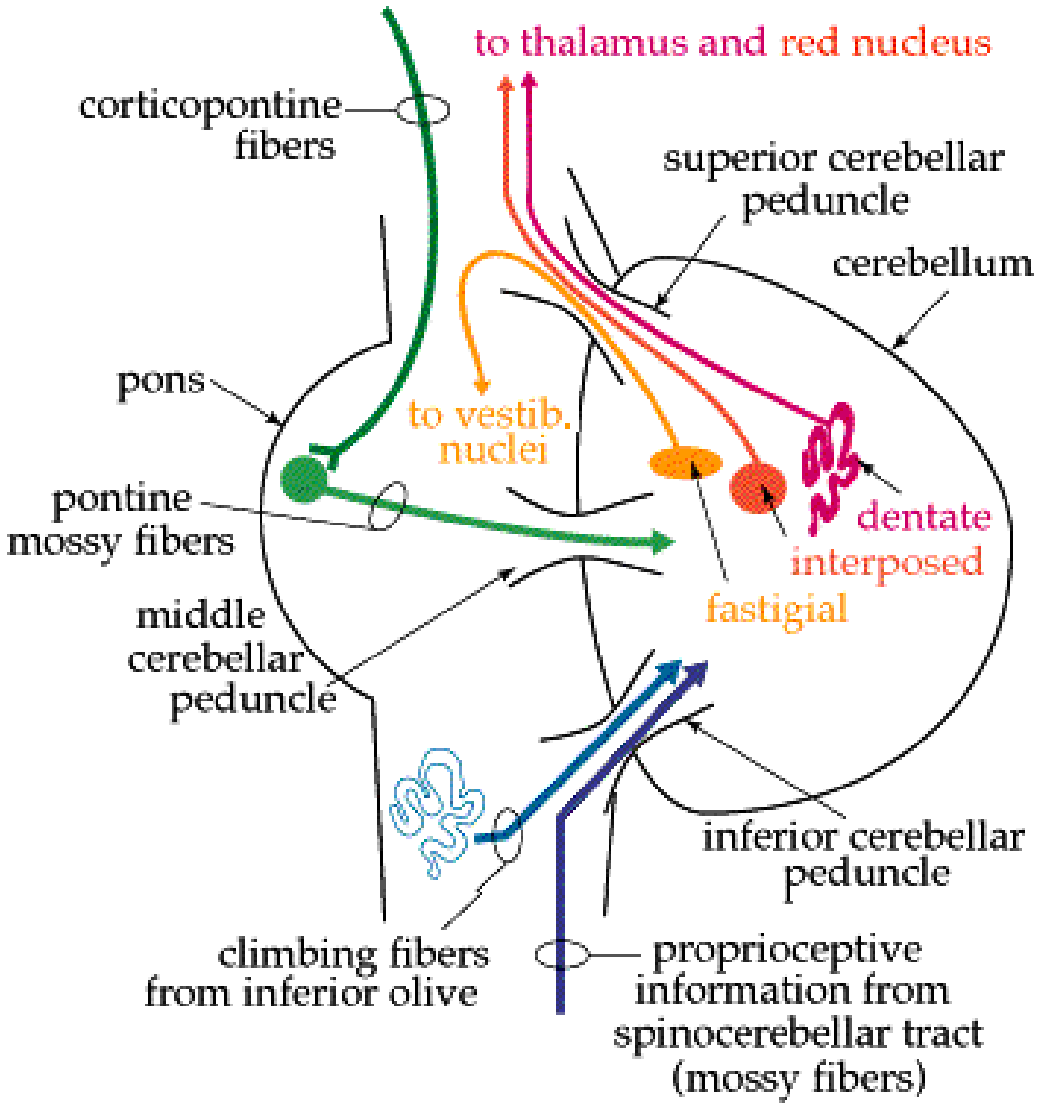
- The cerebellum operates in 3's:
  - there are 3 highways leading in and out of the cerebellum,
  - there are 3 main inputs, and
  - there are 3 main outputs from 3 deep nuclei. They are:



CEREBELLAR PEDUNCLES

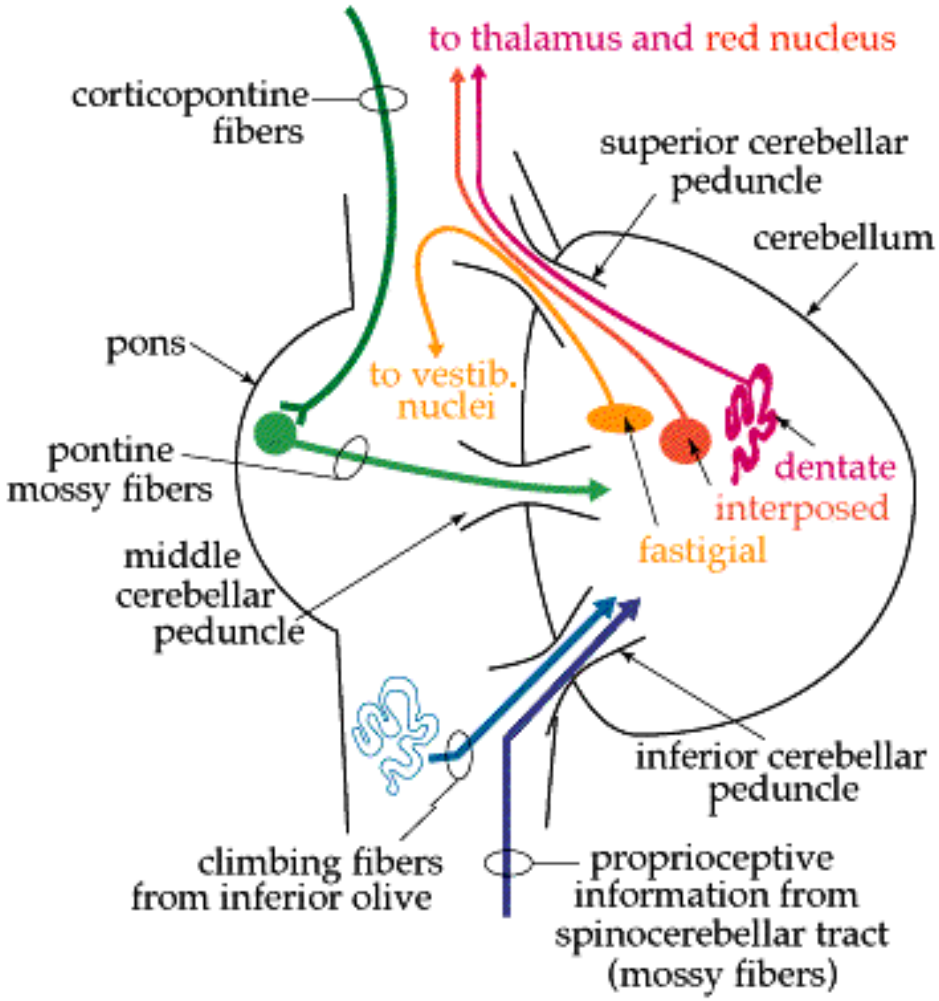
- bundles of fibers connecting the cerebellum with the underlying brain stem

- There are 3 pairs:
  - **inferior-** transmit info about ongoing movement from spinal cord
  - **middle-** sensory info from pons
  - **superior-main output path**
    - info to thalamus and brain stem
    - info to red nucleus of midbrain (red nucleus relays info from cerebellum to spinal cord)



The 3 deep nuclei are the

- **fastigial**- is primarily **concerned with balance**, and sends information mainly to vestibular and reticular nuclei.
- **interposed**, and **dentate nuclei-** The dentate and interposed nuclei **are concerned more with voluntary movement**, and send axons mainly to thalamus and the red nucleus.



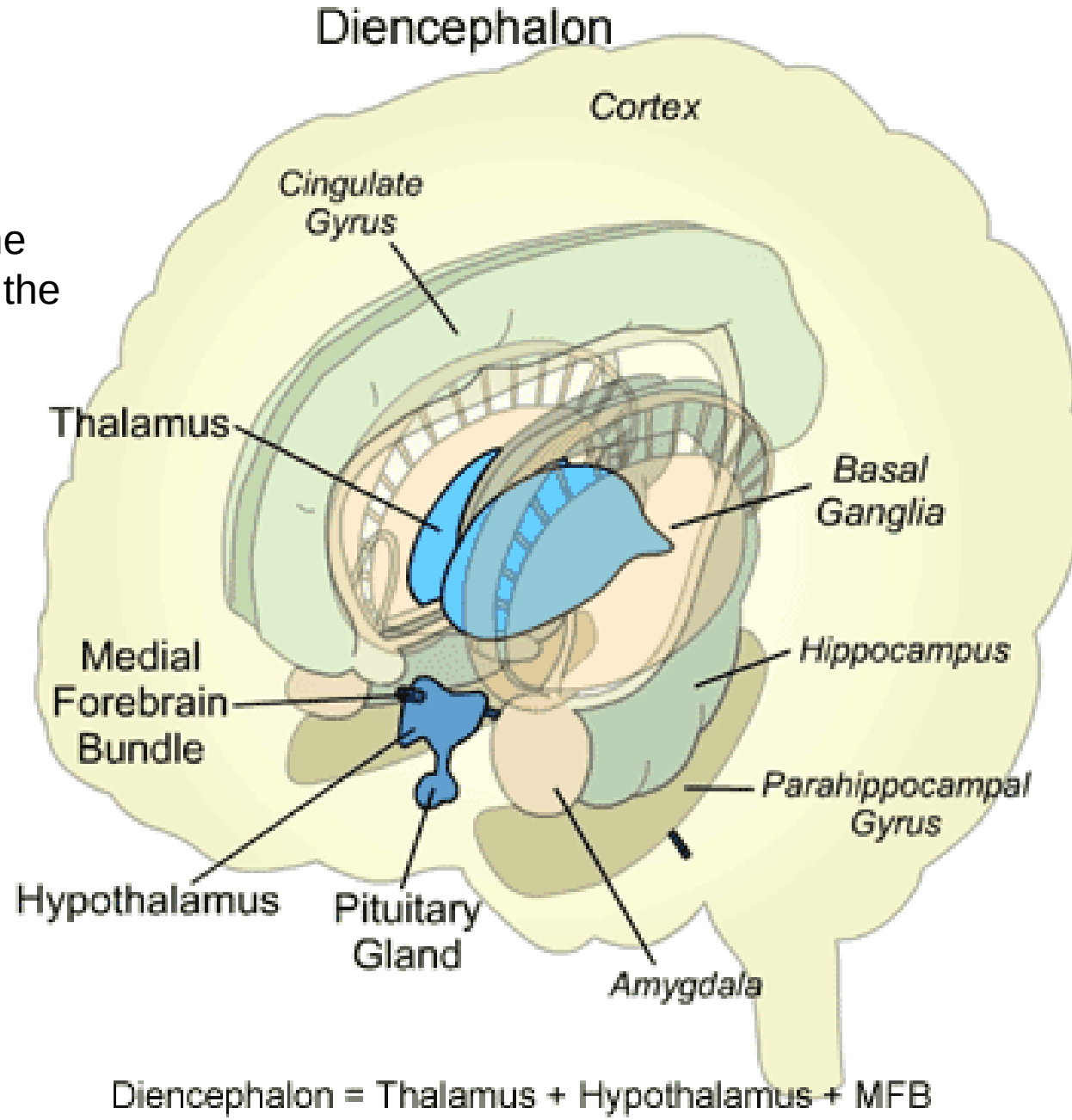
Clinical deficits associated with cerebellar lesions

- Dysmetria (inability to correctly judge distance) or past pointing
- dysdioadochokinesia- inability to carry out fast alternating movements
- intention or movement tremor
- nystagmus- eye condition characterised by rapid, jerky eye movements
- dysarthria- speech disorder charactorized by slow, weak imprecise, and uncoordinated
- hypotonia

The **diencephalon** is part of the forebrain and is located above the midbrain.

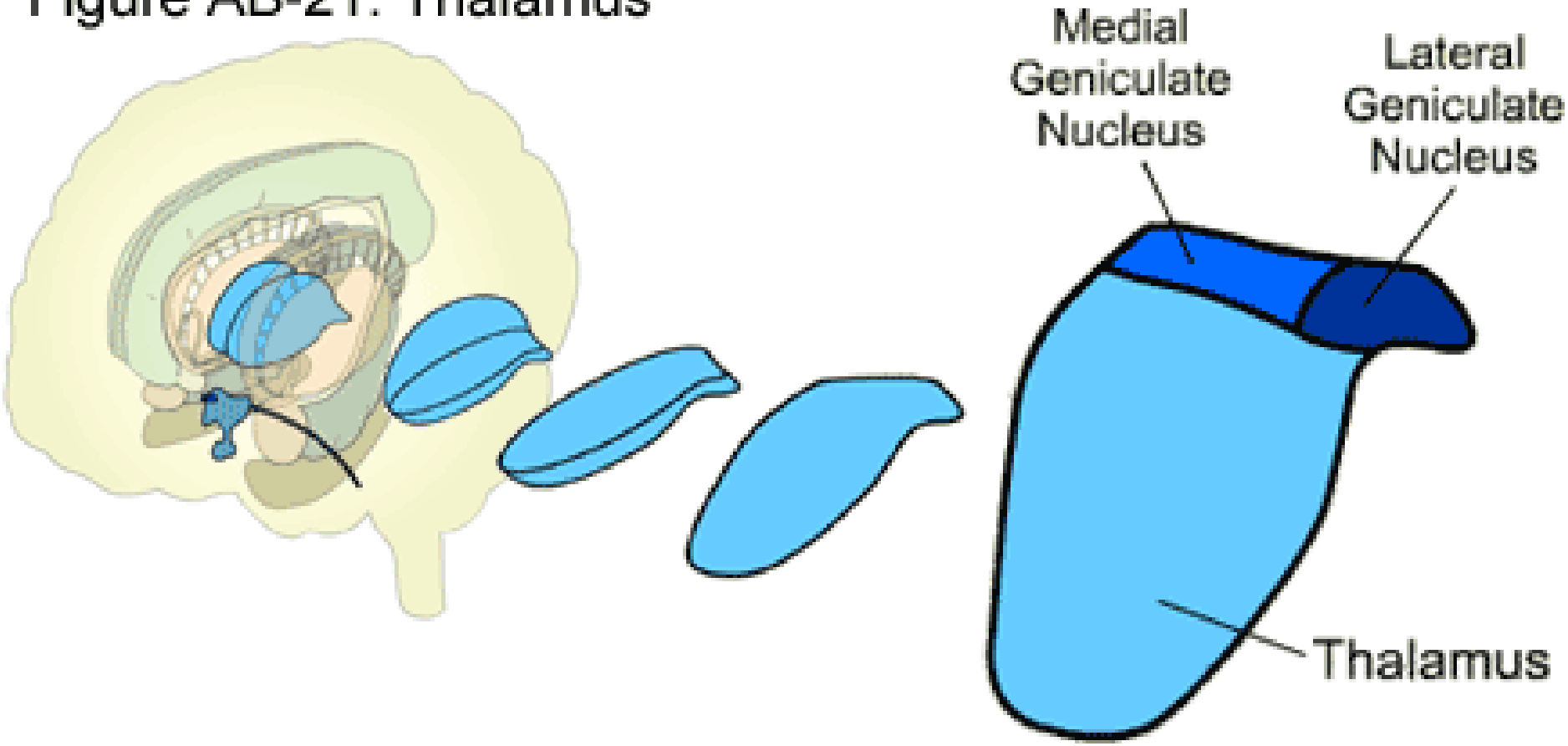
•It contains two major organs:

- thalamus
- hypothalamus.



Diencephalon = Thalamus + Hypothalamus + MFB

Figure AB-21: Thalamus



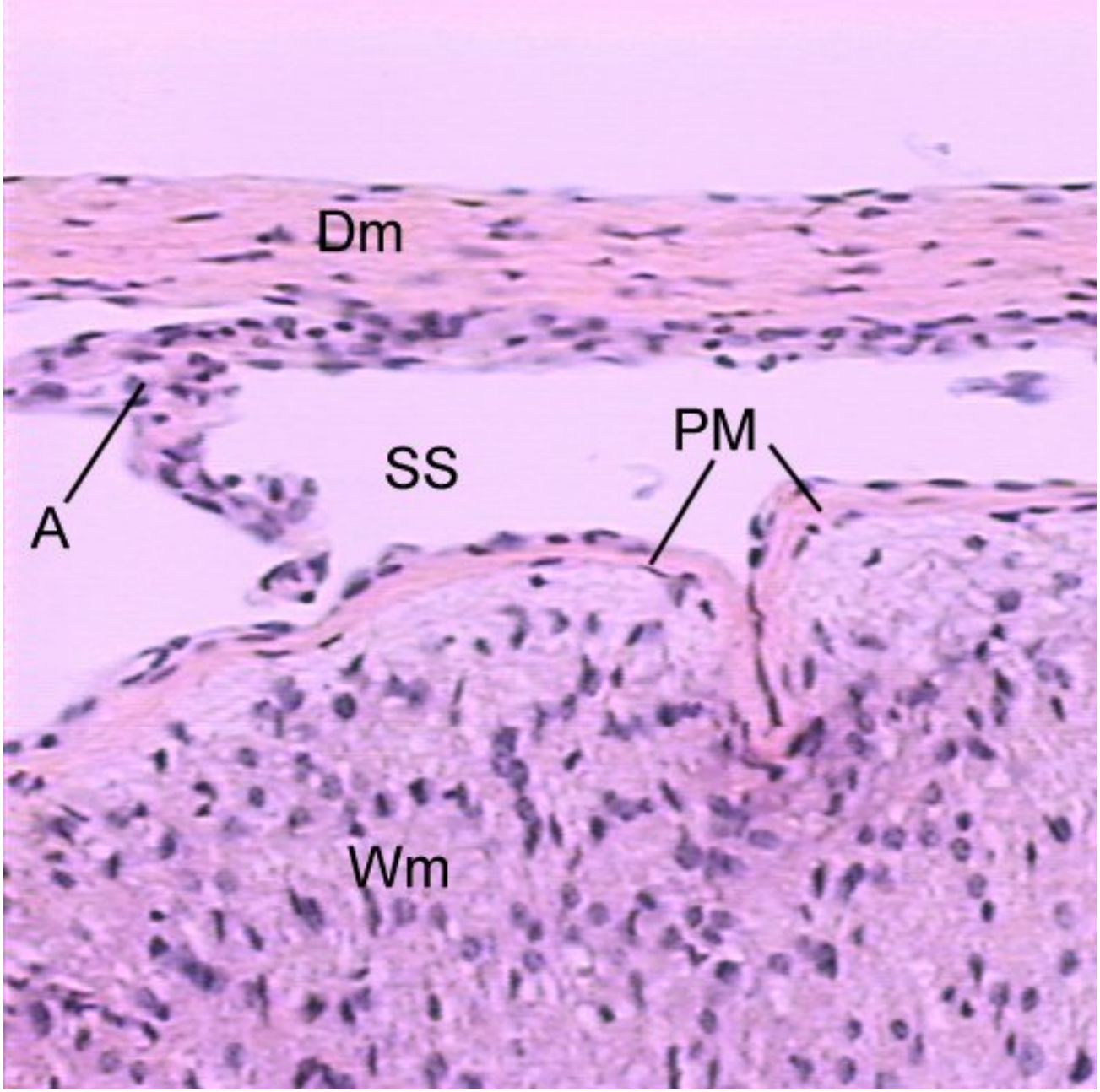
The thalamus is a major **relay center to the cortex for all sensations** except for smell.

consists of many nuclei, including the

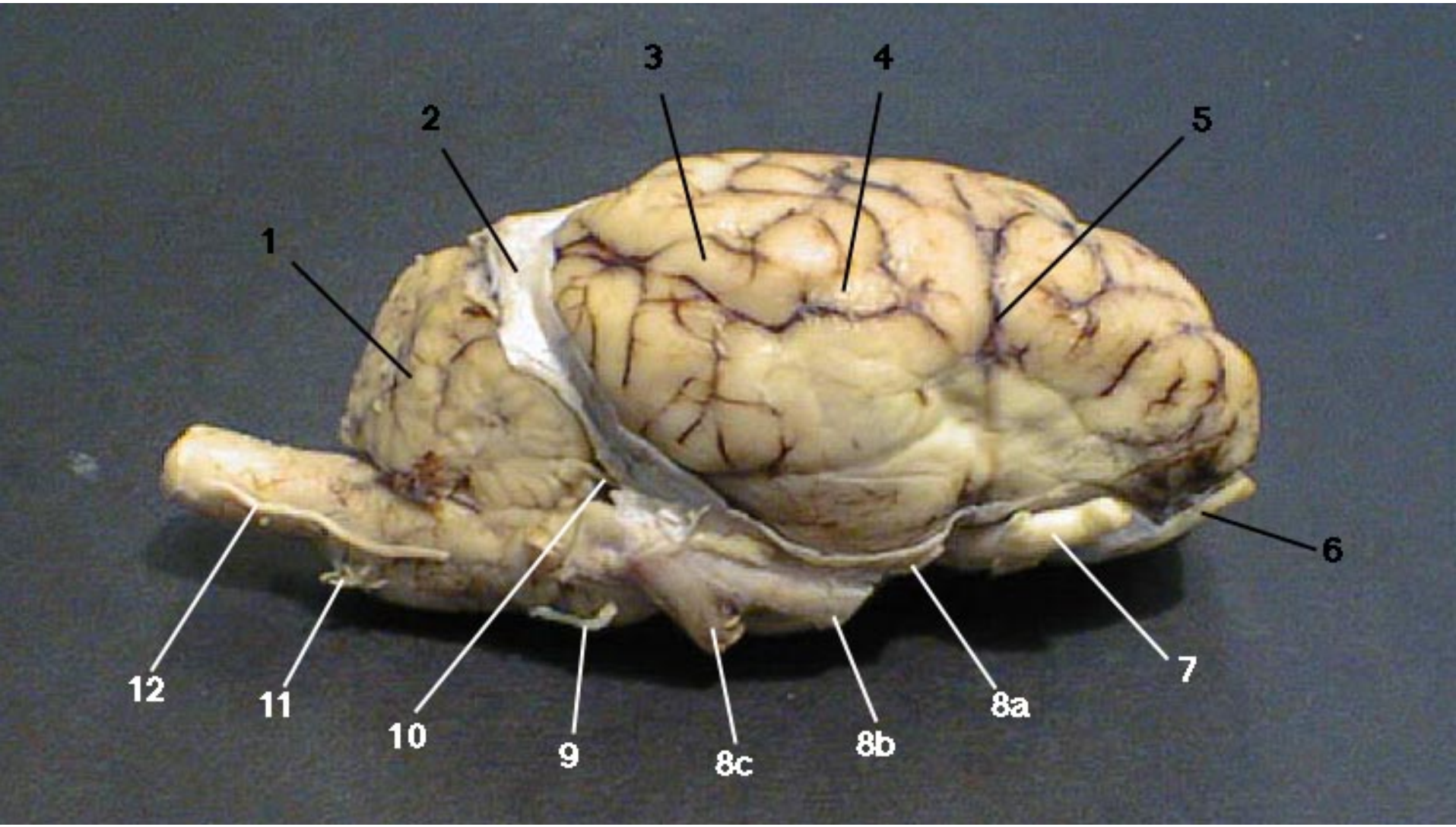
- **lateral geniculate nucleus**- transmits visual information,
- **medial geniculate nucleus**- transmits auditory information.

Hypothalamus

- lies just inferior to the thalamus.
- governs reproductive, homeostatic and circadian functions.
- integrates autonomic and endocrine functions with behavior.
- controls the pituitary gland.
- coordinates the peripheral (see peripheral nervous system) expression of emotional states.



Dm - dura mater; SS - subaracnoid space; A - aracnoid; PM - pia mater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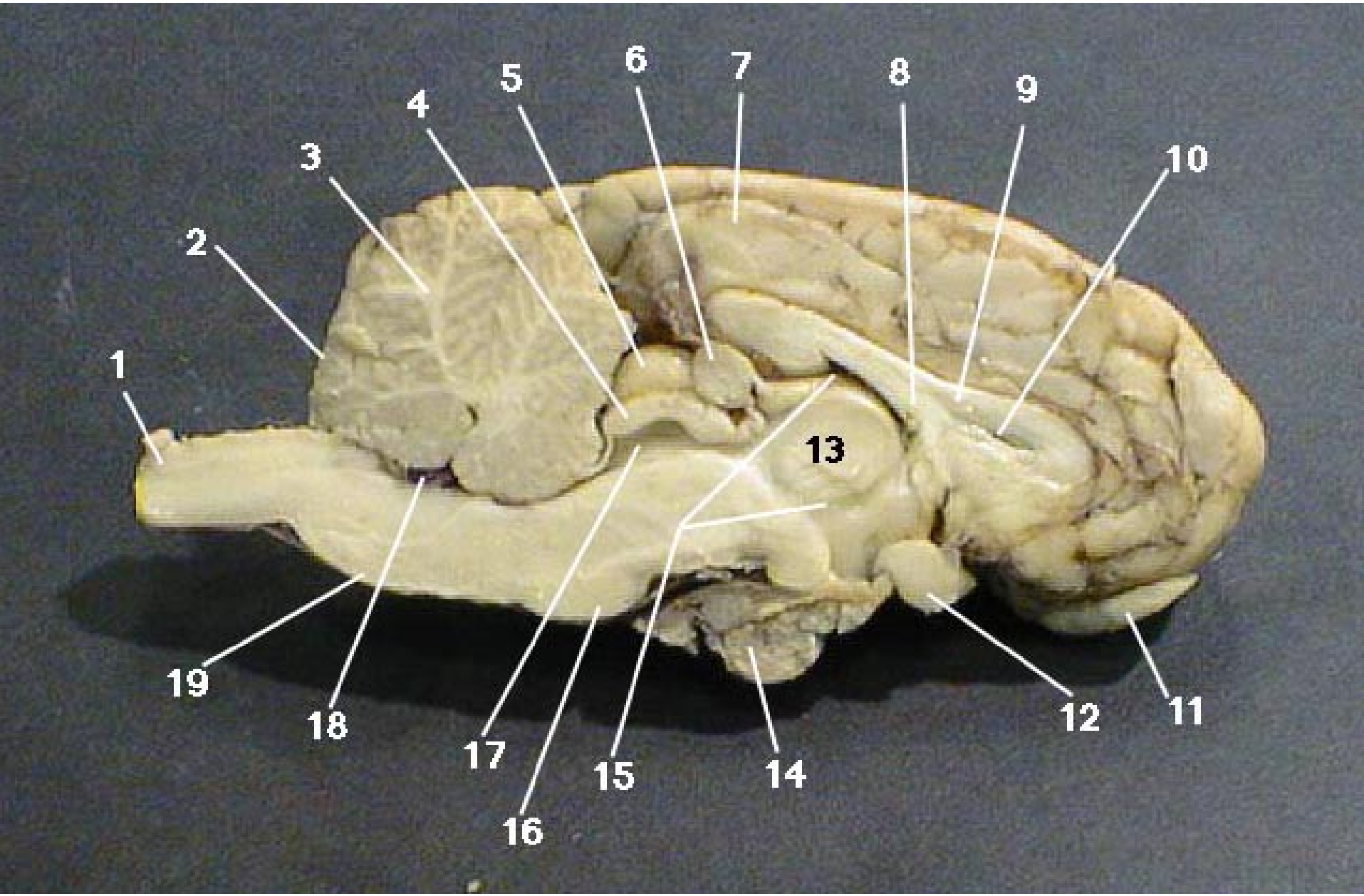
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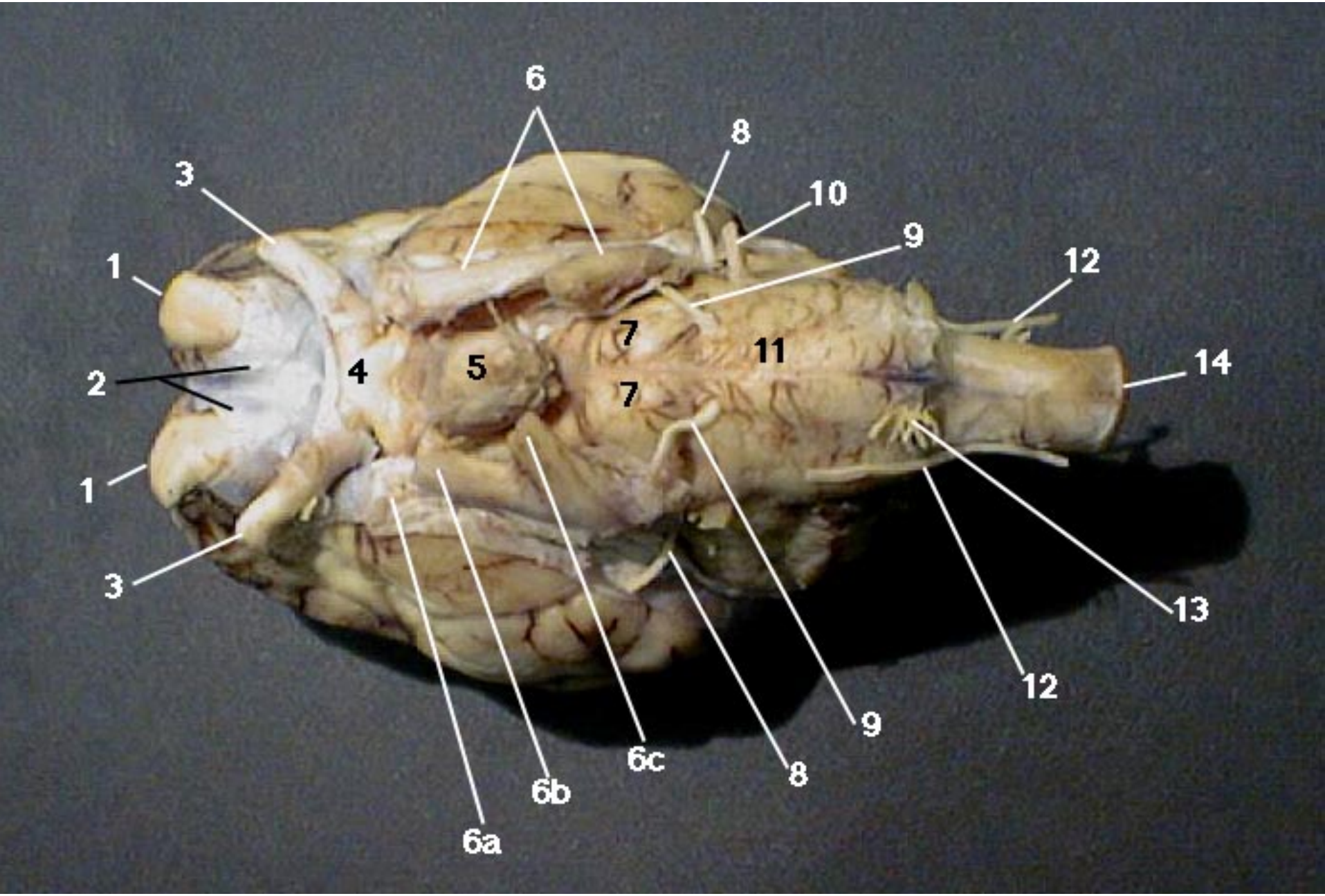
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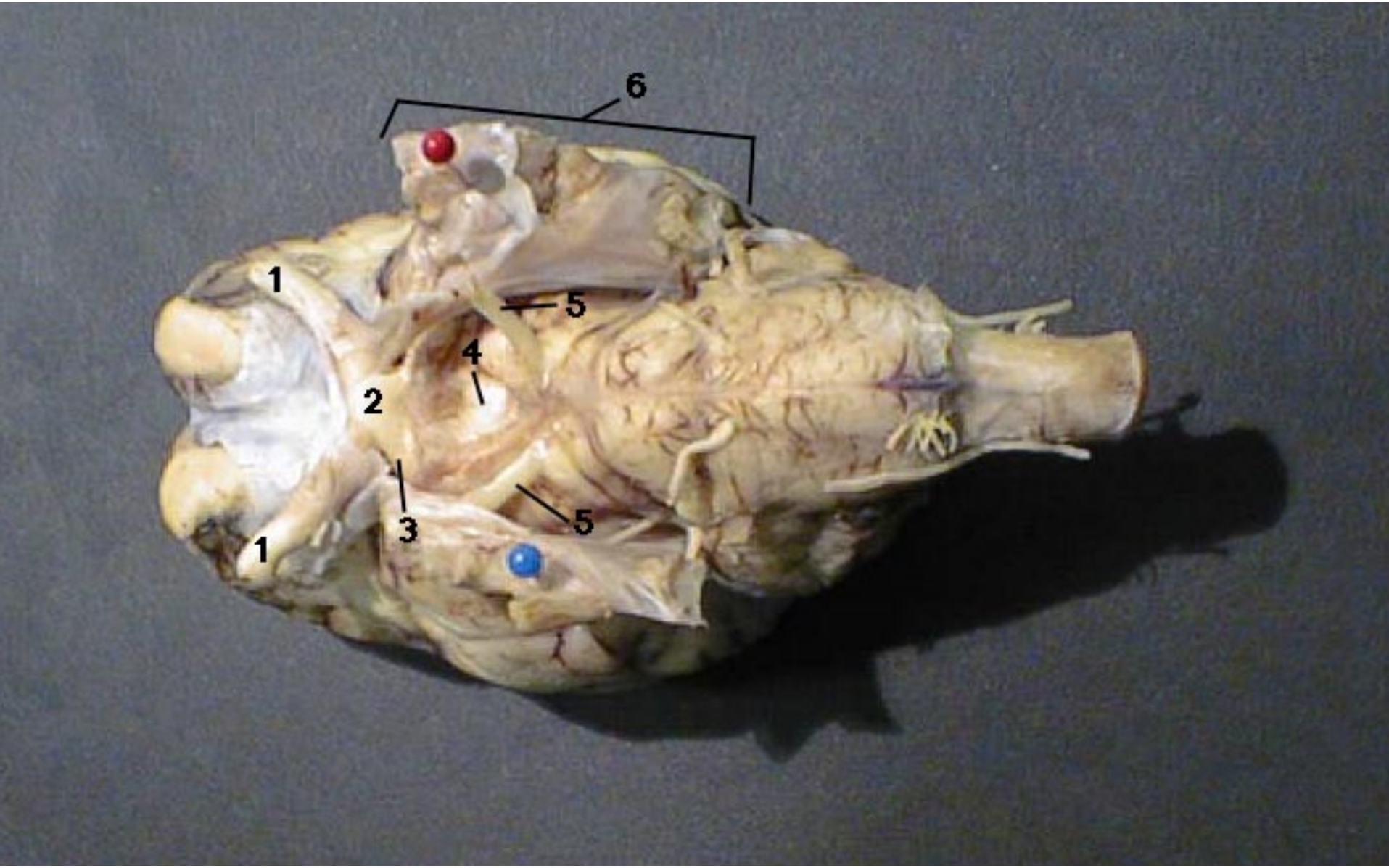
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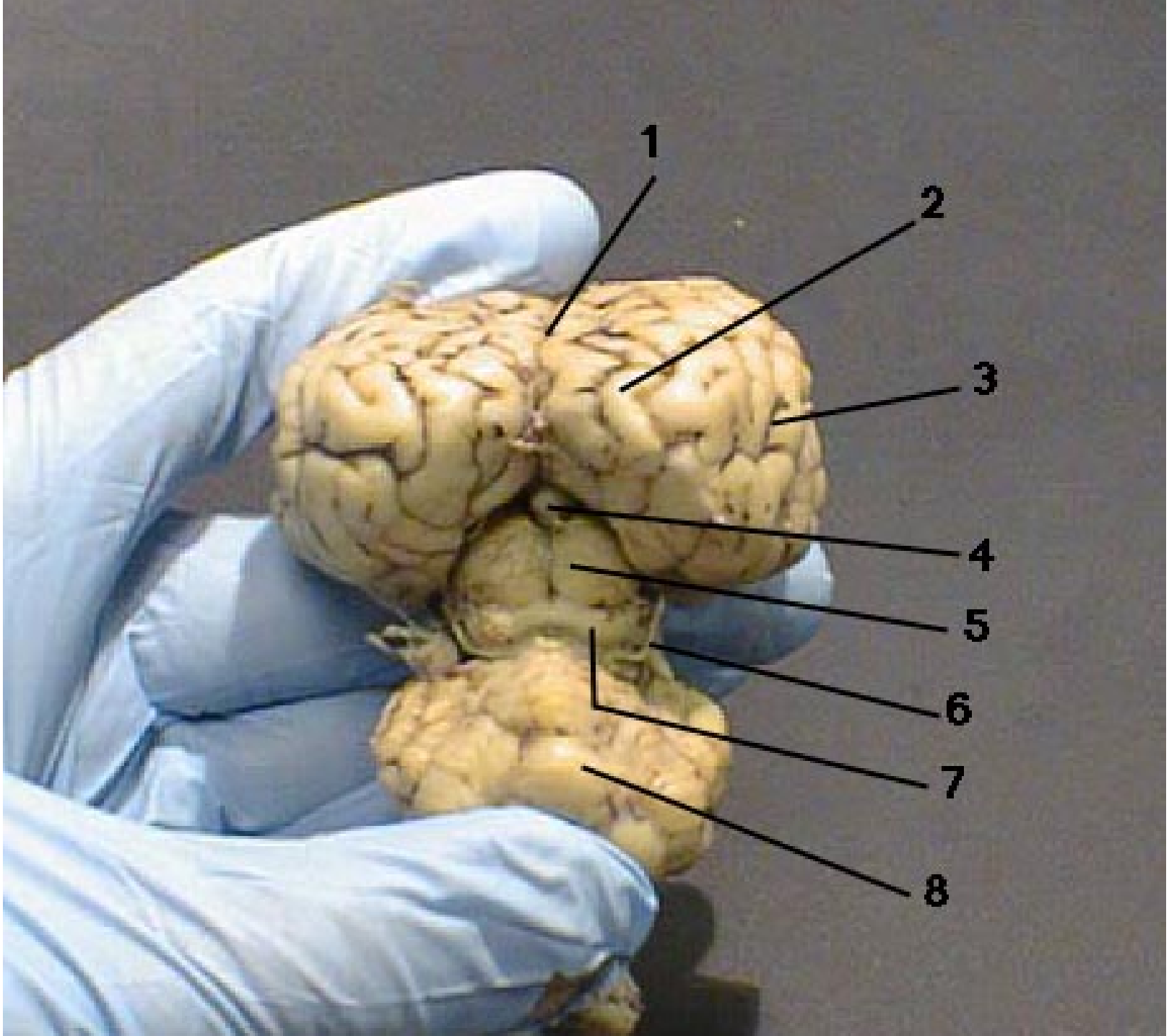
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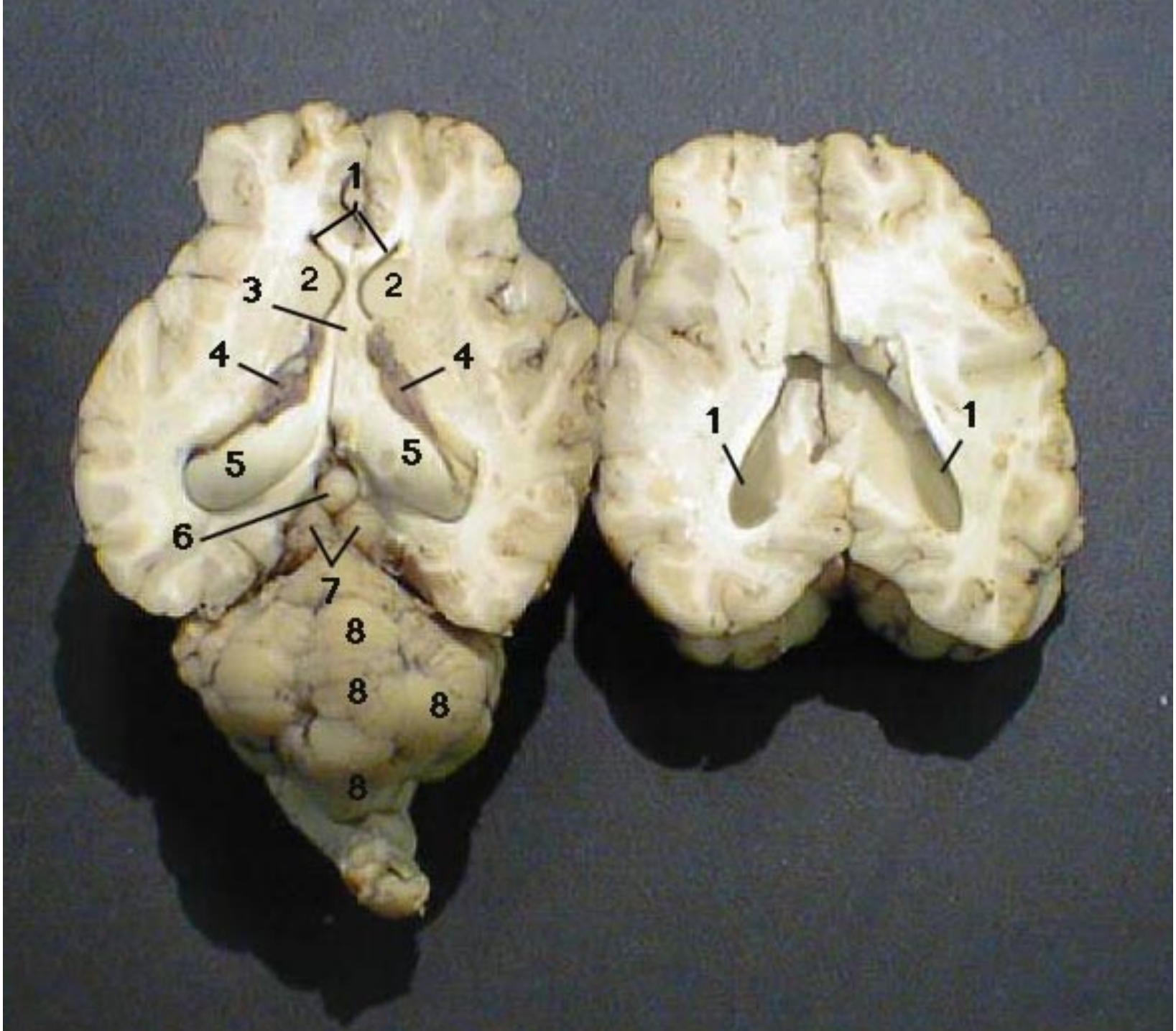
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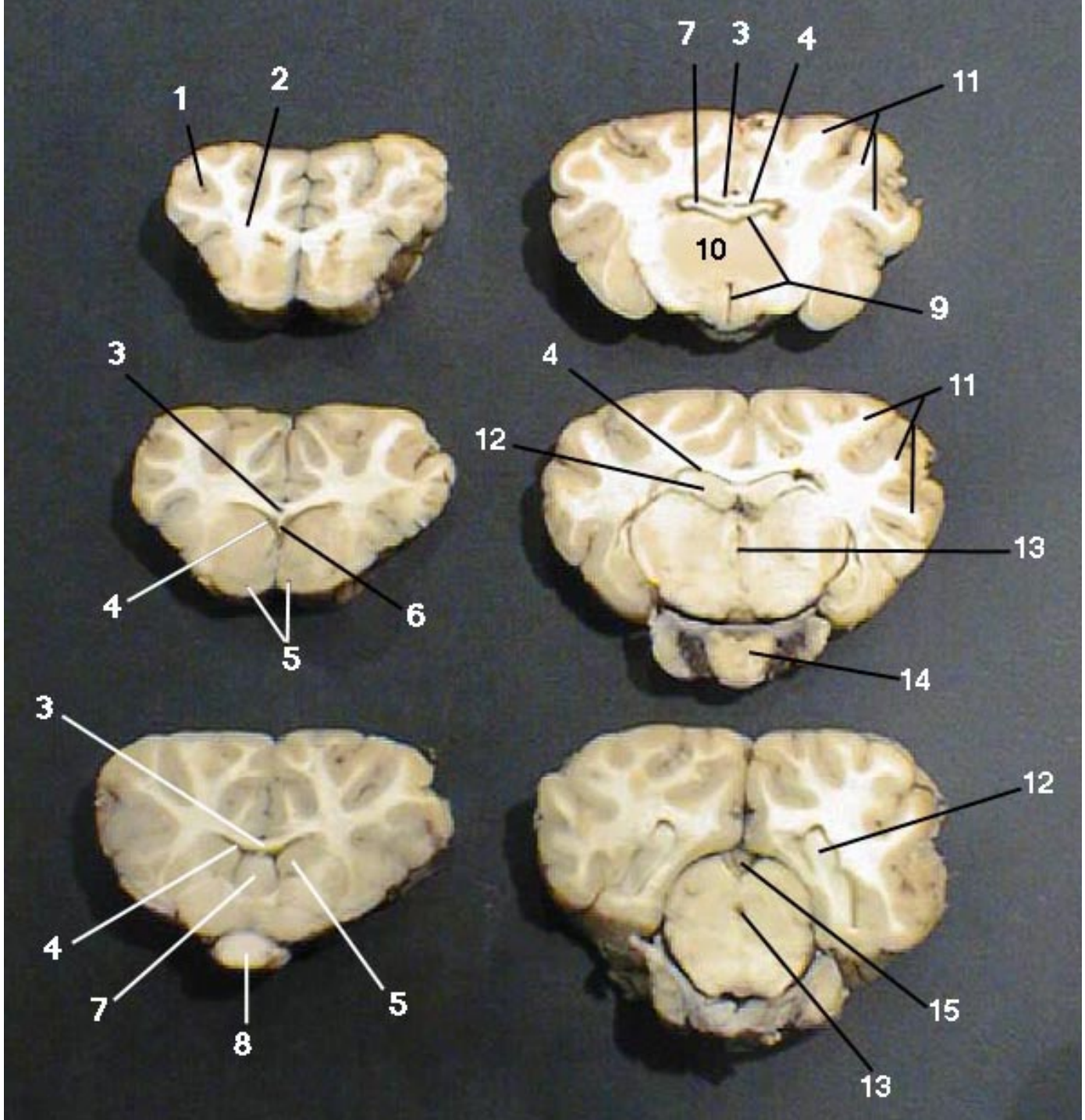
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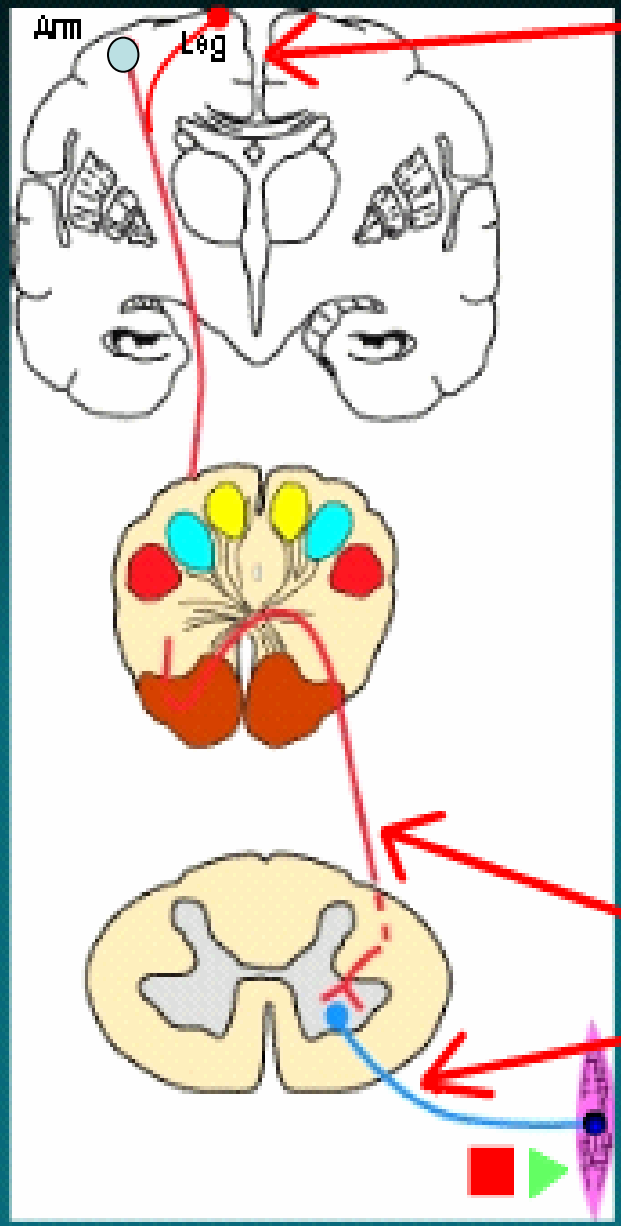
Basics: Corticospinal System



The system arises primarily from the motor cortex of the frontal lobe in the dorsal and medial areas.

Fibers destined for the leg area of the spinal cord originate most medially in the area supplied by the anterior cerebral artery, whereas fibers to the trunk and upper extremity regions originate more laterally and are supplied by the middle cerebral artery.

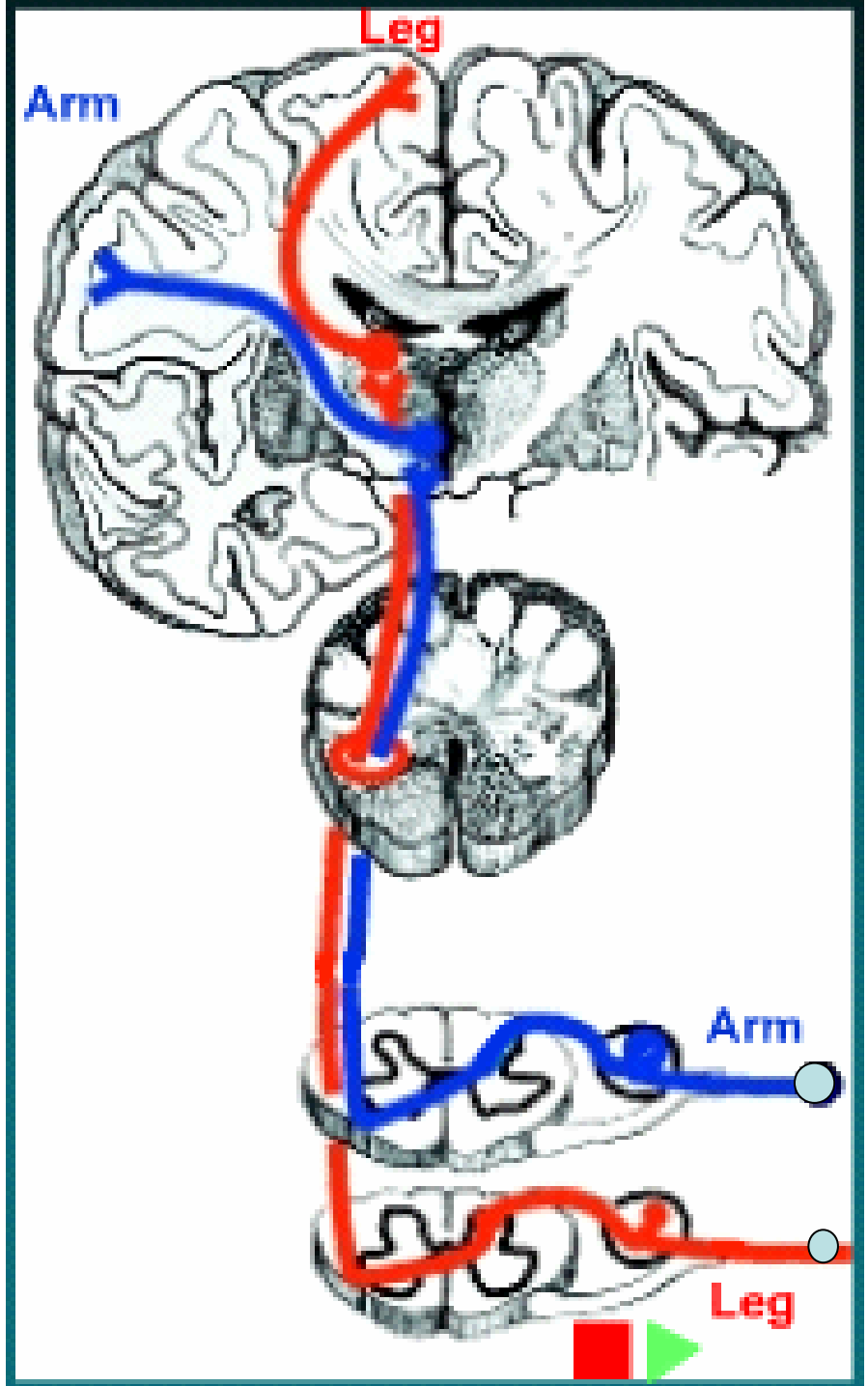
This is an UPPER MOTOR NEURON system. It regulates the activity of the anterior horn cells (LOWER MOTOR NEURONS).

In the caudal medulla, the system crosses to the opposite side to become the lateral corticospinal tract of the spinal cord.

Spinothalmic Tract

This system conveys pain, temperature & light touch

- The information crosses to the opposite side of the cord near the entry level.
- It then ascends through the cord and brainstem as the spinothalamic tract.
- It synapses in the thalamus.
- It then is relayed via thalamocortical fibers through the posterior limb of the internal capsule (PLIC) to the postcentral gyrus of the parietal lobe.

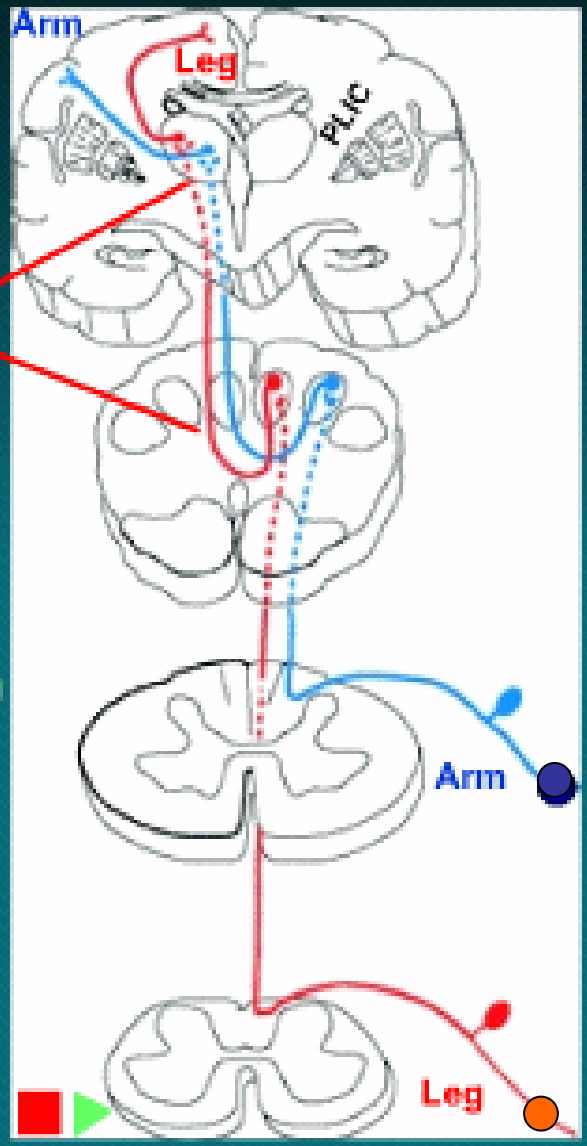


Basics: Post Column Paths & Medial Lemnisucs

This system conveys touch (fine tactile), vibration and position sense

1 The system from the lower extremity (shown in red) is called the fasciculus gracilis and it is located most medially in the posterior aspect of the spinal cord.

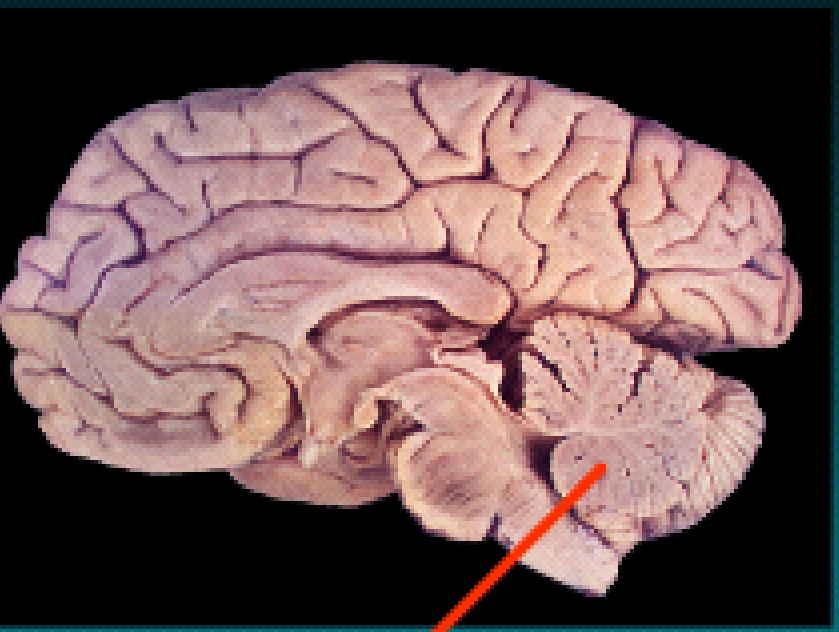
2 The system from the upper extremity (shown in blue) is called the fasciculus cuneatus and it is located most laterally in the posterior aspect of the spinal cord.

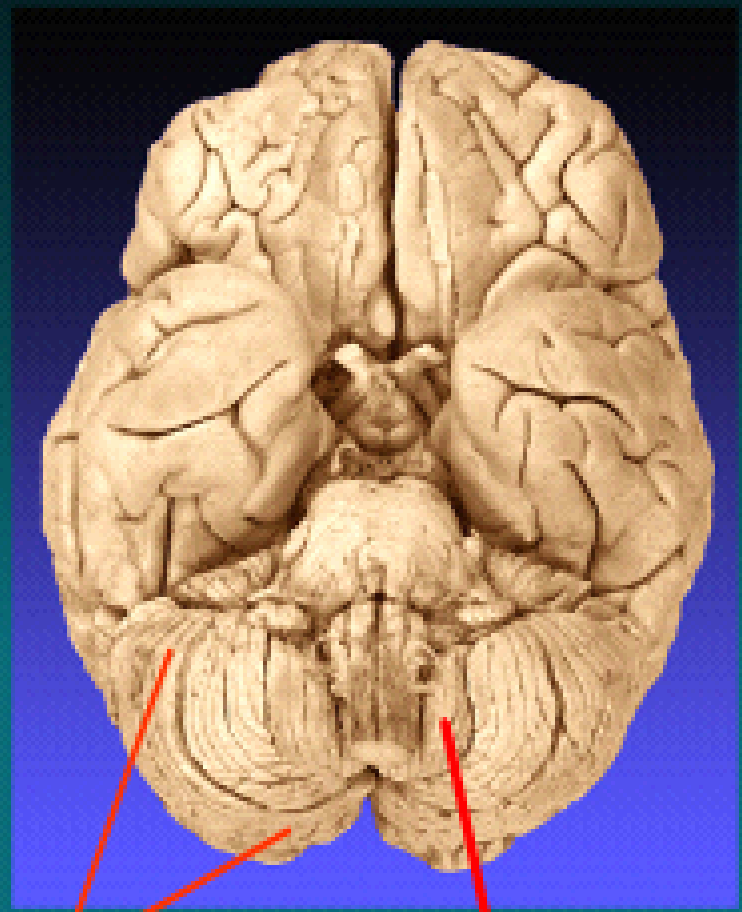


3 In the caudal medulla the system crosses and is then called the medial lemniscus as it ascends through the brainstem to the thalamus.

4 It also is relayed via thalamocor-tical fibers through the posterior limb of the internal capsule (PLIC) to the postcentral gyrus of the parietal lobe.

Cerebellum Midsagittal & Ventra



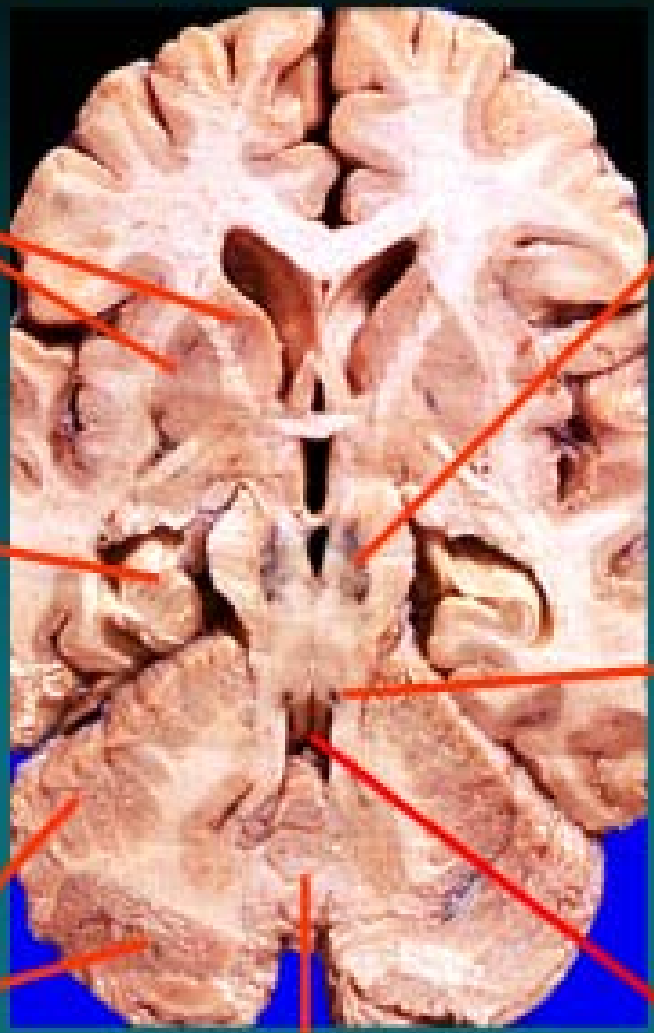


Vermis

Cerebellar Hemisphere

Tonsil

Horizontal View



Striatum
(Caudate & Putamen)

Substantia Nigra
(Dopamine)
(Parkinson's)

Hippocampus

Locus Ceruleus
(Adrenergic)

Cerebellar Hemisphere

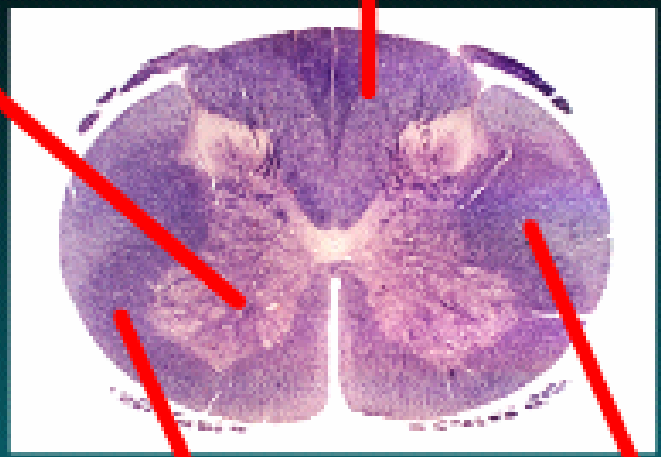
Vermis

4th Ventricle

Spinal Cord

ANT HORN CELLS

- LMNs
- Ipsilateral loss
- Weakness
- Fasciulations
- Paralysis
- Abnormal EMG
- Atrophy



POST COL PATHS

- Lesions produce ipsilateral loss
- Touch (fine)
- Vibration
- Position sense

SPINOTHALAMIC TR

- Lesions produce contralateral loss starting 1 or 2 levels below lesion level
- Pinprick & temp
- Light touch

CORTICOSPINAL

- Lesions produce ipsilateral upper motor neuron signs
- Weakness
- Increased DTRs,etc.
- Babinski sign